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The Journal of the Biological Photographic Association

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VOLUME II NUMBER 1

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The Journal of the Biological Photographic Association

will contain articles on

Photomicrography
Cinematography
Cinemicrography
Clinical and Gross Photography
Lantern Slide and Motion Picture Projection
Processing Room Technic
New Ideas and Equipment
New Processes and Developments
Zoölogical and Botanical Photography
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Published Quarterly

THE PURPOSE of this Journal is to keep the biological photographer posted in the latest developments in photographic technic, and the proper use of equipment and materials in relation to the biological sciences. It will contain articles by authorities in the fields of biological photography. They will tell, in simple language, how to obtain what are ordinarily considered difficult pictures in the easiest possible manner. They will discuss new equipment and its uses. The Journal will have pictures and articles on advanced photographic apparatus constructed by the research workers in the photographic departments of the foremost American and foreign Universities, including Medical and Dental Schools.

It will be the most complete source of technical information for the biological photographer. This Journal is sent to members of the Biological Photographic Association. The dues to this Association are $3.00 per year, of this amount $2.00 is for a year's subscription. For non-members of the Association the subscription price is $2.00 per year or $.50 per copy.

If you are a producer of any type of biological photography, if you photograph anything that is alive or has been alive you can not afford to be without this association and publication to advance in your profession. It will be to your benefit to mail your subscription to the Editorial Office of the Journal, or much better pay the extra dollar and become a member of the Association and receive the Journal free.

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JOURNAL OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

MT. ROYAL AND GUILFORD AVES., BALTIMORE, MD., U. S. A.

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Journal of the Biological Photographic Association

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From Photochronography and Biotachygraphy to Cinephotomicrography..... *Oscar W. Richards* 39

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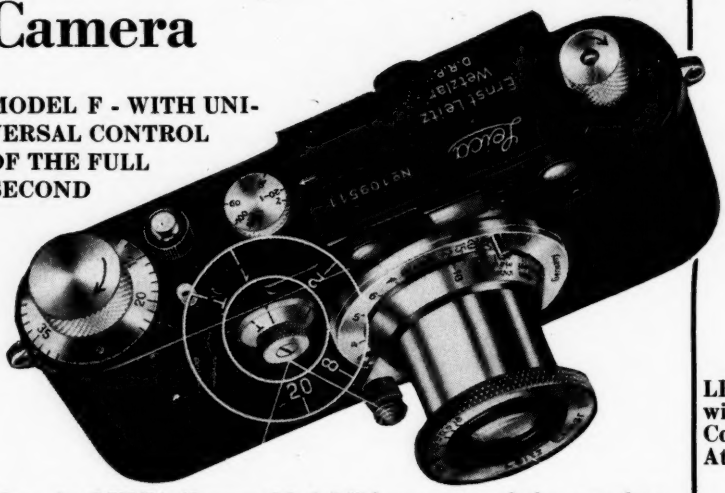

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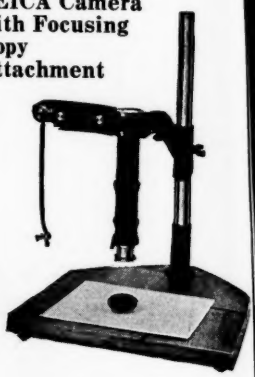

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VOLUME II *September, 1933* NUMBER 1

The Journal of the Biological Photographic Association

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EDITORIAL

The third annual convention of the Biological Photographic Association will be held in Rochester, N. Y., on September 14, 15 and 16 of this year. This meeting of biological photographers will undoubtedly be the most outstanding convention that has ever been held by this association.

There will be many interesting papers on the program, some of which are as follows:

"Some Interesting Motion Picture Technic," by Heinz Rosenberger. (To be illustrated with 35 and 16 millimeter film.) Rockefeller Institute For Medical Research.

"Commercial Aspects of Clinical Photography," by Arthur W. Fuchs, Eastman Kodak Co.

"Technical Aspects of 16 Millimeter Medical Motion Picture Work," by H. B. Tuttle, Eastman Kodak Co.

"Photomicrography with the Finlay Color Process," by Jean Kieffer, Norwich State Sanatorium.

"The Photographic Department of a Non-Teaching Hospital, Organization and Character of Work," by Helen Hanson, St. Francis Hospital.

In addition to this the Eastman Kodak Company will entertain the members and guests of the association at luncheon, after which they will be taken by taxicabs to Kodak Park where guides will conduct them through the Eastman factory. On the completion of this instructive tour the members and guests will be taken to the theater of the Kodak Research Laboratories where a demonstration of some of the more in-

teresting photographic procedures of both still and motion picture work will be held. In addition to this tentative program there will be other papers to be read, a discussion and banquet.

The Power's Hotel of Rochester has been chosen for the convention headquarters. Members of the association and others interested in this type of photographic work are cordially invited to attend. All persons coming to the convention should register at the Biological Photographic Association's desk in the Power's Hotel, Rochester, N. Y., between 8:30 and 9:30 a.m. on September 14, 1933.

A program of the convention will be mailed to all members of the association. Non-members may obtain a program by writing to Mr. Ralph P. Creer, Department of Photography, United States Veterans Administration Hospital, Hines, Illinois.

ORTHOCHROMATIC AND COLOR CONTRAST PHOTOGRAPHY*

WALTER CLARK

From the Research Laboratory Eastman Kodak Company

Natural objects are characterized, as far as the eye is concerned, by their form, and the way they reflect or transmit light. If they have the property of modifying the spectral quality of light which falls on them, they possess the attribute which we know as color. The forms of objects are apparent to us because they represent differences of brightness or of color, either in themselves or by comparison with other objects. The purpose of photography, if we ignore photography in natural colors, is to record these brightness differences, or to translate the color differences into brightness differences in the photograph. It so happens that the majority of natural objects are colored, and the problem before the photographer is to record the tones of these colored objects in their relative brightness values as seen by the eye, or in some distorted ratios of brightness if it is desired to emphasize certain characteristics.

The reproduction in monochrome of colored objects in the relative brightness values seen by the eye, is the function of *orthochromatic photography*. *Color contrast photography* is concerned with deliberate modification of these visual brightness values. The successful photography of colors in any desired monochrome tone value demands a knowledge of the photographic film or plate, particularly its response to light of different colors, an understanding of the sensitiveness of the eye to light of different colors, and a knowledge of the color of the light source used for illuminating the subject being photographed, and the means of modifying that color in any desired manner.

It is unnecessary to discuss here the nature of light and color. However, in order to obtain the best results in the photography of colored objects, it is convenient to think of color in a way which is the converse of that in which it is usually regarded. For example, it is customary to think of a piece of green glass as green because it transmits green light, or a piece of blue paper as blue because it reflects blue light. White light, however, can be regarded as consisting of blue-violet, green and red light—the visible spectrum can be divided into three approximately

* Received for publication January 25, 1933.

equal portions, having respectively these colors. Green glass, therefore, can be considered to be green because it absorbs the parts of the spectrum which are not green, that is, the blue-violet and red. Similarly, blue paper looks blue because it absorbs green and red light, and reflects only the blue. We are justified in saying that anything which absorbs blue-violet and red light together will be green; anything that absorbs green and red light together will be blue. It is valuable to have in mind this conception of color as an absorption. It is important because it defines the color of an object without reference to the color of the light falling on it.

A yellow object is not necessarily one which reflects yellow light. There is very little yellow light indeed in the spectrum, and if an object reflected only yellow light it would be so dark as to be almost black. A yellow color is due to absorption of blue light. The other colors of the spectrum, green and red, are reflected, so that we can regard yellow as consisting of green plus red, but we shall prefer to regard it simply as lack of blue. Yellow, then, is white minus blue.

We are now in a position to understand what is meant by *complementary colors*. The top line in figure 1 represents the components of white light. In the second line, the blue has been blotted out, leaving a mixture of green and red, that is, yellow. We say, then, that yellow is complementary to blue. Similarly, in the next line, the blue and green are removed, leaving only red, so that red is complementary to blue-green. In the bottom line, the blue and red are removed, leaving green. Green is complementary to this mixture of blue and red, which is usually known as magenta.

In general, therefore, the light absorbed by an object is said to be complementary to that reflected (or transmitted) by it. Complementary colors, when added together, result in white.

We have so far considered only the intense primary colors and imagined that a red object absorbs the whole of the blue-violet and green. In the majority of cases in nature, however, the absorption is incomplete—we have only partial absorption, and this can be of two kinds: it can be *sharp*, or it can be *gradual*. It is of interest to examine the effect of a single sharp absorption band in different parts of the spectrum. Consider a narrow, sharp absorption band about 650mμ in the red, and producing a complete absence of red in this part. The remaining color consists of all the blue-violet, all the green and part of the red, and the

actual visual effect of this is the color known as "sky-blue." "Sky-blue," then, may be called a *residual color,* being due to the residue of colors left after a sharp red band has been removed.

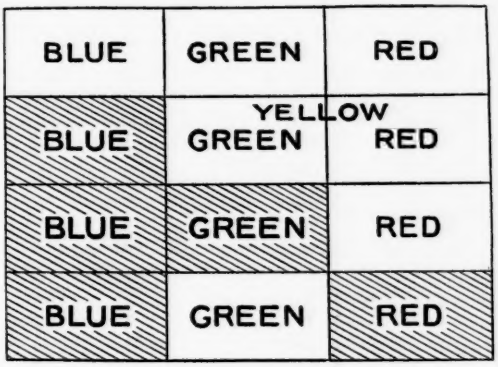

FIG. 1. CHART SHOWING COMPLEMENTARY COLORS

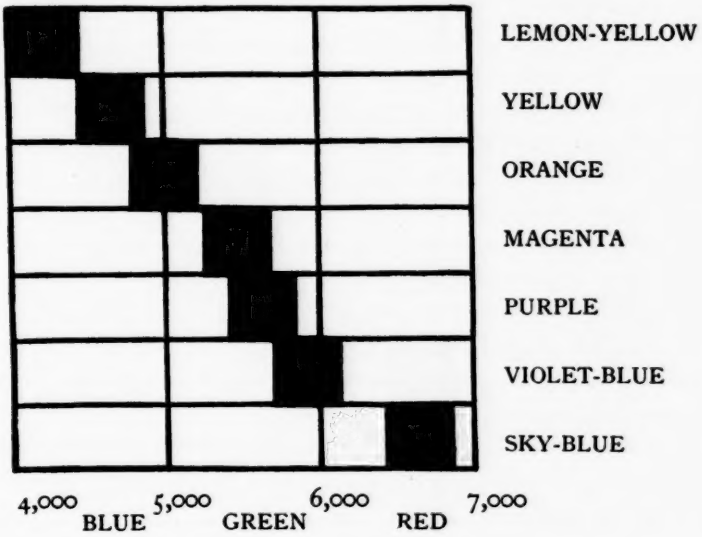

FIG. 2. CHART SHOWING RESIDUALS

Imagine this band to shift to other parts of the spectrum, and other residual colors result, as shown in figure 2, due to Dr. C. E. K. Mees. It will be noticed that the color green does not enter into this series at all. It is not possible to get a green color by using a white-light spectrum and

removing a single narrow band. In order to get a residual green, it is necessary to have absorption both in the red and in the blue, i.e., two absorption bands. If these bands vary in regard to each other, we get various shades of green.

Natural colors do not generally show sharp absorption bands, although some of the stains used in microscopy often do so. However, if a natural object having, say a magenta color, does not signify a sharp, clear-cut absorption in the green, it still means that it absorbs far more of the green than of any other color, and the rules for theoretical residual colors can be applied to natural colors.

So much for the characteristics of color. We must now consider the sensitiveness of the human eye to color. This is not the same for light of all colors. The eye is more sensitive to yellow-green light than to any other color. The eye can see a very dim yellow-green light more readily than it can see a very dim blue or red light, for instance. For bright light the maximum sensitiveness is at about 554mμ. At very low levels of intensity, the maximum shifts to shorter wave-lengths.

Just as the eye does not respond equally to light of all colors, so the photographic film or plate is unequally sensitive to light of different colors. Unfortunately, moreover, the color sensitivity of a normal photographic material does not resemble in any degree the color sensitiveness of the eye. One color, green, appears brightest to the eye, while a different color, violet, appears brightest to an ordinary photographic film or plate. The regular, non-color-sensitive photographic plate responds only to blue and violet light. It sees objects only by the blue and violet light that they reflect, and is quite non-responsive to red, orange, and nearly all the green. This is a serious fault, because the record which such a plate makes of colored objects differs entirely from that which the eye makes.

By the use of certain dyes it is possible to confer on photographic materials a sensitiveness to wave-lengths of light to which they do not of themselves respond. The added sensitiveness occurs approximately in the region of the spectrum in which the dyes absorb. If a film is treated with erythrosine, which absorbs yellowish-green light, it will be sensitive to yellow-green light in addition to violet and blue. Films or plates sensitized to this spectral region are known as "orthochromatic."

By the use of other dyes it is possible to make a film or plate sensitive to all the colors of the visible spectrum—that is, from the violet right through to the red. A material prepared in such a way is known as a

panchromatic film or plate. Figure 3 shows the relative color sensitivities of ordinary, orthochromatic and panchromatic films or plates.

Recently, new sensitizers have made it possible to make panchromatic materials of a wide range of speed and color sensitiveness. It has been found desirable to group these panchromatic materials into three classes,

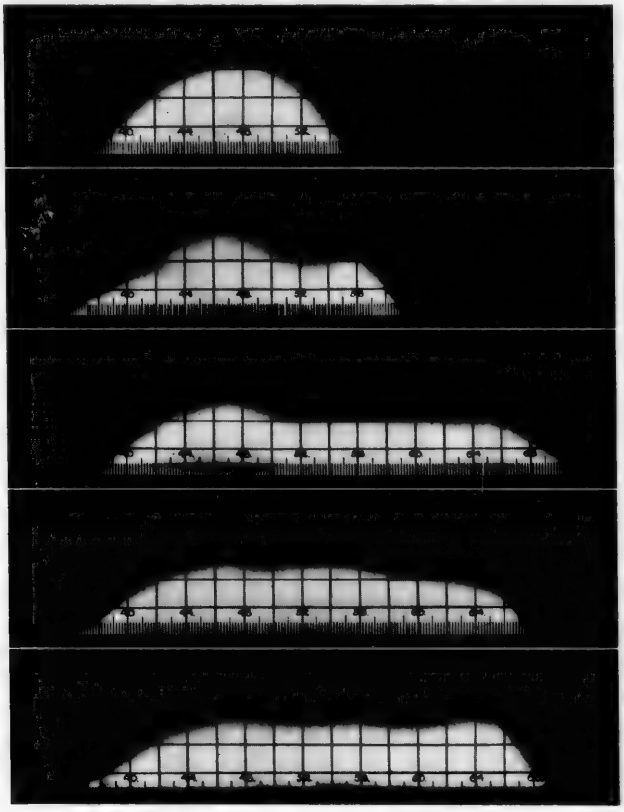

FIG. 3. PHOTOGRAPHS OF WEDGE SPECTRA ON STANDARD PHOTOGRAPHIC MATERIALS
Exposed to sunlight or white flame arc

the characteristics of which are shown in figure 3. In addition, a range of dyes has been found which enables us to confer high sensitivity in selected regions through the visible spectrum.

Because of its lack of sensitivity to green and red light, an ordinary, non-color-sensitized film or plate cannot in any circumstances reproduce

the correct tone values of a colored object, unless it be entirely blue or violet.

An improvement will result if an orthochromatic film or plate, which is sensitive to the yellow-green in addition to the blue and violet, is employed. The orthochromatic material, however, is insensitive to some of the visible colors, particularly the reds, and so cannot give a faithful rendering of all tones as seen by the eye. A panchromatic material, on the other hand, is sensitive to all colors, and by its aid a result can be obtained which approximates more closely to the truth. The ideal photographic material would have a response curve, when used with a given quality of illumination, identical with that of the eye. Such a material does not exist. All photographic films and plates, even of the panchromatic variety, are *far more sensitive* to blue, violet and the invisible ultra-violet light than they are to green and red. In any photograph, therefore, which is made with a light source which contains any appreciable amount of blue light, such as natural daylight, or the carbon arc, the effect of the violet and blue will still predominate over that of the green and the red, and a false rendering will result. A considerable improvement will be obtained if an artificial light source such as an incandescent tungsten lamp is used with a panchromatic film or plate. Such a lamp gives very little energy in the blue end of the spectrum, and consequently compensates to some extent for the enhanced blue sensitivity of the material.

A satisfactory result is obtained if the light reaching the plate or film is modified by passing it through an absorbing layer, known as a light filter, which removes all the ultra-violet and as much of the blue and violet light as is necessary. *Such a filter is called an orthochromatic filter.* Its color will depend on the color sensitivity of the plate or film and the spectral quality of the light used with it. Its function is to absorb such of the light that the effective response curve of the film or plate resembles that of the eye.

With the older types of panchromatic plate or film, the orthochromatic filter had to absorb ultra-violet and blue light only, and consequently was yellow in color. An example of this type of filter is the well-known Wratten K2 filter. Some of the modern panchromatic materials, particularly those known as super-sensitive or hypersensitive panchromatic, have a very high sensitiveness to red light and in order to get with them correct tone rendering it is necessary to absorb some red as well as some blue light, and the orthochromatic filters are green in color. Examples

of these are the new Wratten X1 and X2 filters, the transmission curves of which are shown in figure 4.

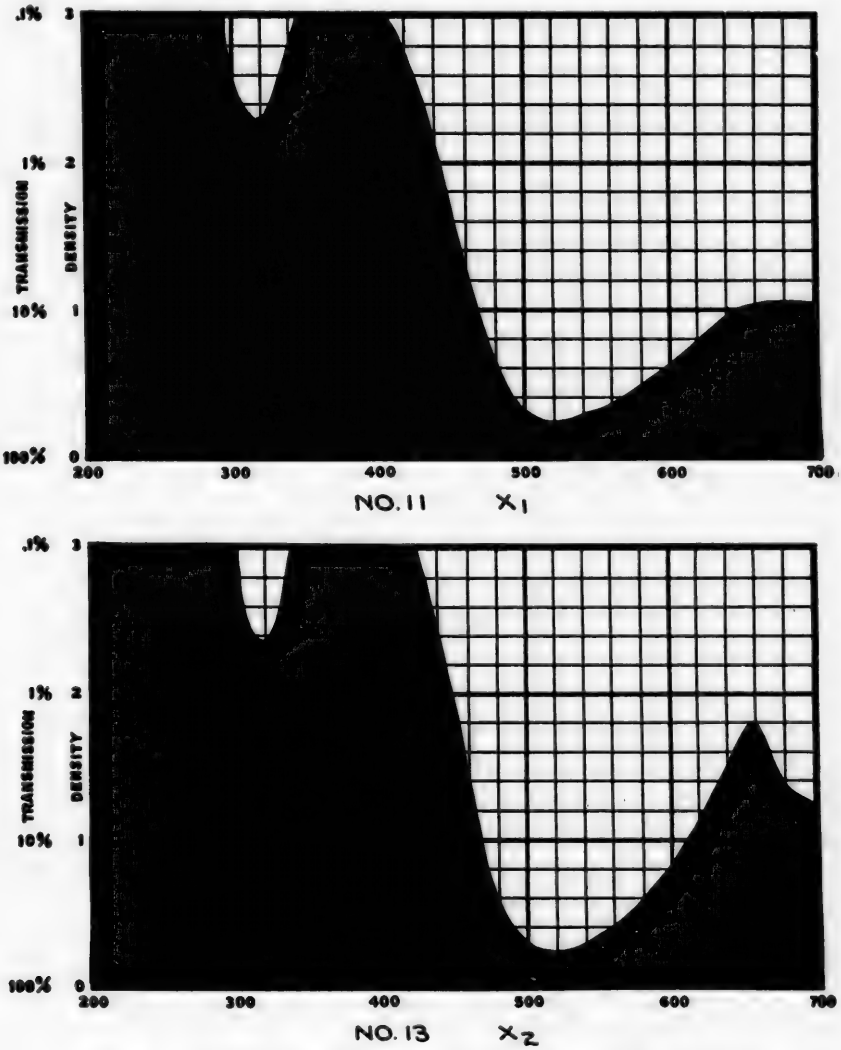

FIG. 4. TRANSMISSION CURVES OF WRATTEN X1 AND X2 FILTERS

In order to obtain true orthochromatic rendering with different light sources and the three modern varieties of panchromatic materials, the following filters should be used:

K2 filter, with Type B (orthopanchromatic) materials in daylight or the white flame carbon arc light.

X1 filter, with Type B materials in clear or frosted bulb tungsten light, and Type C (hyperpanchromatic) materials in daylight or the white flame carbon arc light.

X2 filter, with Type C materials in clear or frosted bulb tungsten light.

With Type A materials, the most suitable filter is the K2, although the correction is not quite so good, there being a little under-correction in the green.

Since the function of an orthochromatic filter is to absorb light it must necessarily result in an increase of exposure of the plate or film. The number of times by which the exposure must be increased for a certain filter with a given material is known as the *multiplying factor of the filter*, or, in short, the *filter factor*. This factor depends on the characteristics of the film or plate with which it is used, and on the light source. It is meaningless to refer to filters as "two times" or "four times" filters, as is frequently done.

In the manufacture of filters the dyes are so selected that they completely absorb the ultra-violet light and just so much of the visible colors as is necessary, and no more. Also, as a filter is invariably used in conjunction with a photographic objective, often a highly corrected anastigmat giving good definition, care should be taken in the manufacture of filters to ensure that they do not degrade the definition of the lenses with which they are used.

If a filter is too strong, in other words, if too much of the spectrum is cut out by it, the photograph will appear *over-corrected*. For instance in landscape photography, if the filter employed is too deep, atmosphere in the distance will be lost, the sky will appear too dark, and green grass and foliage may appear too light. In flower photography, yellow flowers may be indistinguishable from white ones.

In many instances, of course, over-correction is deliberately resorted to. In survey work and aerial photography, where the utmost detail is desired, rather than pictorial quality, it is necessary to remove all haze and atmosphere and for this purpose a strong yellow filter, such as the Wratten "G" or "Minus Blue" (No. 12), is best. Atmospheric haze scatters violet and blue light, but freely transmits red. In order to eliminate the flattening effect of haze, therefore, a filter removing all blue and violet light is employed. For photographing cloud forms against the sky,

it is often desirable to exaggerate greatly the contrast between the cloud and the sky, and for this purpose a red filter, Wratten "A," is suitable.

These *contrast* filters, such as the "G" and the "A", differ from the orthochromatic filters in that they are what is known as "*sharp-cut.*" There is as sharp a transmission as possible between the region of absorption and that of transmission. The orthochromatic filters have a gradually increasing absorption.

To the eye, objects are distinguished from their surroundings by contrast which may be of two kinds. It may be tone contrast, that is, contrast of light and shade, or it may be color contrast. Tone contrast can always be correctly reproduced photographically, but the result of the reproduction of a color contrast will depend very definitely on the photographic method used.

Suppose we have a bright red apple in a cluster of green leaves. The tone contrast is very small, though the color contrast to the eye is very marked. Photographed on an ordinary film or plate, which is insensitive to green and red light, both will reproduce dark and a mass of black will be recorded in which apple and leaves are indistinguishable. Now suppose we use a Wratten Panchromatic Plate with a K2 filter and daylight as the illuminant. This gives correct tone rendering as seen by the eye, and again the contrast between apple and leaves disappears and they are represented by a uniform field of gray.

In order to obtain a satisfying reproduction of this color contrast, we must sacrifice the correct rendering of either the red or the green. If we use a green filter, the leaves will appear lighter and the apple darker. If we use a deep orange filter the red apple will appear lighter than the leaves. Whichever we use must be governed by circumstances, although it is best to over-correct towards the red, since red, as a rule, seems more brilliant to us than green.

In scientific and technical photography it is very often desirable to overcorrect deliberately in order to emphasize contrast.

If it is desired to photograph a colored object so that a certain color appears black, it must be photographed through a filter which will completely absorb that color. Then, no light reflected by it will reach the plate, and, consequently, it will reproduce as black.

Consider a photomicrograph of a section stained with eosine. Its color is pink. If viewed or photographed in blue light, it will appear comparatively light because eosine does not absorb blue. By blue-green light

of a wave-length 500–540 mμ, which is absorbed completely by eosine, the section is entirely black, blocked up in detail, and of maximum contrast. Photographed at 570 mμ, which is near the edge of the absorption band, a considerably lessened contrast results, which gives the best result for this particular section. There is plenty of detail, and yet sufficient contrast. Photographed at 640 mμ in the red, in light which is completely transmitted by the section, there is practically no contrast at all.

For maximum contrast, then, the subject must be photographed in the absorption band. This is a rule to remember. In the case of the eosine-stained preparation just considered, we were concerned with contrast of the object against the background, and ignoring contrast within the object itself.

If it is desired to photograph a uniformly colored thing so as to get *the best rendering of detail, it must be photographed not in its absorption band, but in the transmission or reflection region of the color.* A good example of this is the photography of an unstained section of whalebone. This is yellow in color and full of detail. Photographed for maximum contrast in blue light, which is absorbed by it, it shows great contrast, but practically complete loss of detail. However, photographed by red light which it transmits, it shows ample detail. Insect preparations require this type of treatment. Photographed in yellow or red light, they give quite satisfactory results.

In order to show up the grain of wood it should be photographed on a panchromatic material in light of the color which it reflects. Mahogany should be photographed using an orange-red ("A") filter; yellow woods such as oak, satinwood, walnut, and so on require a strong yellow filter, such as the "G" contrast filter. A red filter is of little advantage.

Consider a print with a yellow stain of which it is desired to make a copy so that the stain shall be invisible. An ordinary film or plate is sensitive only to the blue or violet, colors which are absorbed by the yellow stain. If a copy is made, therefore, on an ordinary plate, the stain will appear black. On the other hand, if it is photographed on a panchromatic plate through a strong yellow filter, such as the "G" filter, the yellow stain will fail to photograph.

Negatives which have been processed under difficult conditions in the field, as, for instance, on an expedition or during wartime, are frequently imperfectly fixed and washed. On storing, they develop a brown stain in the parts containing any silver bromide or fixing salt which was not re-

moved. Prints made in the regular way from such negatives are very irregular in density, and have light parts corresponding to the stained areas. Satisfactory negatives of good printing quality can be made by printing the stained negatives on to a panchromatic material through a deep yellow or light red filter, and using the resulting print in the manner of a negative to make a "duplicate negative" by printing it onto a non-color-sensitive film or plate.

In copying engineer's or architect's blue-prints, unsatisfactory results are obtained if an ordinary plate, or an orthochromatic plate with a yellow filter are used. To obtain best results a Process Panchromatic Plate should be used with a red filter ("A" or "F") which completely absorbs blue.

In order to obtain contrast in a photograph, it has been said above that it is necessary to photograph in light of a color which is completely absorbed by the part of the subject which it is desired to render dark. An alternative way of doing this is to use a photographic material which is insensitive to the color it is desired to render dark, and which has a high degree of sensitivity to the color it is desired to reproduce light. This method does not give the scope obtainable by use of a panchromatic plate and suitable filter, although it may be of value in special cases.

An interesting case which recently came to the author's attention concerned the photography of green (live) and brown (dead) pine needles, in such a way as to give contrast between them in the negative. To the eye there appeared to be considerable contrast, although use of regular panchromatic plates with the usual deep yellow, green and red filters failed to give much differentiation in the negative. Now, chlorophyll has a very strong absorption band at about 670mμ in the red, so that green pine needles strongly absorb light in this region of the spectrum. On the other hand, the brown needles reflect red light very well. It should have been possible, then, to obtain a satisfactory photograph, using a plate having a high degree of sensitiveness at 670mμ, and confining the exposing light to a narrow spectral band around that wave-length. The Eastman Spectroscopic Plate, Type 1-F[1] has a sharp maximum of sensitivity at 670mμ, falling off rapidly to practically nothing at 700mμ. Using such a plate with tungsten lamps and a Wratten No. 70 filter, which

[1] *Photographic Plates for Use in Spectroscopy and Astronomy*, obtainable from Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

FIG. 5A. PHOTOGRAPH ON ORDINARY PLATE

FIG. 5B. THE SAME AS FIGURE 5A, BUT ON INFRA-RED SENSITIVE PLATE BY INFRA-RED LIGHT

transmits freely only beyond 660mμ, a negative showing appreciable contrast resulted.

During the past year considerable progress has been made using plates sensitive to the infra-red region of the spectrum. Records to wavelengths beyond 1200 mμ have been obtained, and a number of different types of infra-red sensitizing are available,[1] having maxima at 760 mμ, 810mμ, 860mμ and 960mμ. Many materials have reflection and transmission characteristics in the infra-red which are quite different from those in the visible region. Many materials which look identical in visible light appear vastly different when photographed in the infra-red, and vice versa (see fig. 5). This is the case with many dyed materials, for instance. In portraits by infra-red light the flesh appears chalky, the red lips come out very light and are indistinguishable from the flesh, the eyes appear as small black circles, and all lines in the face are enormously exaggerated.

The chlorophyll of the leaves of deciduous trees reflects infra-red light very well and the foliage of such trees photographed in the infra-red appears almost white. Incidentally, the foliage of coniferous trees does not appear to reflect the infra-red nearly as well, and it is generally possible to distinguish readily in a picture between deciduous and evergreen trees, even if their shapes are not discernible.

Certain bodies transmit infra-red light much more freely than visible light, and photomicrographs have been made of insects by infra-red in which the photograph had the appearance of a radiograph. It is possible to make "shadowgraphs" of certain bodies, such as the human hand, which transmit infra-red light relatively freely.

The field of infra-red photography is well worth the attention of biologists. It is likely to be of as much value to them as ultra-violet photography, and no special apparatus is required.[2] All that is necessary is an incandescent tungsten source of light, a filter transmitting only in the extreme red (Wratten 25, 89-A, 87, etc.), and infra-red sensitive plates.

[2] *See "Photography by Invisible Light—Infra-Red Photography,"* W. Clark, *Amer. Photo.*, 1932, *26*, December., 675–680.

ILLUMINATION SYSTEMS FOR PHOTOMICROGRAPHY BY TRANSMITTED LIGHT*

W. ZIELER

E. Lietz, Inc.

The illumination system of a photomicrographic apparatus is a compound optical unit which has several points of resemblance to the optical system of the microscope itself. Its correct alignment is as important as that of the microscope, but it sometimes offers greater difficulties. When the microscope is correctly focused, a sharply defined image appears on the ground glass. Whether the illumination system is correctly aligned cannot be determined by one single and definite criterion. In fact, there are differences of opinion among microscopists as to the task to be fulfilled by the illumination system. A discussion of the optical principles is of no particular practical interest but many microscopists may benefit by explanations of existing illumination systems and description of their alignment.

Under consideration of the theoretical and practical problems involved, the requirements for satisfactory illumination may be summarized as follows:

A. Requirement for illumination of an area of definite diameter: The diameter of the field of view depends upon the objective and eyepiece used. It varies from several mm. for low magnification to 0.1–0.2 mm. for the highest oil immersions.

B. Requirement for uniform illumination: The intensity of the illumination at the periphery must be equal to that in the center or any other part of the field.

C. Requirement for maximum and variable intensity: The intensity must be uniformly variable by regulation of the aperture of the illumination and must permit a maximum value where this aperture is at least equal to that of the objective.

Any method of illumination which fulfills these three conditions is perfectly satisfactory for photomicrography. This may be emphasized because in some textbooks we find a method known as "critical illumination" recommended as the only one which is correct for photomicrography.[1] It may be described as a system with which an image of the light source is formed in the plane of the object.

* Received for publication April 5, 1933

[1] E. J. Spitta: "Microscopy," 1907.
E. J. Spitta: "Photomicrography," 1899.

Critical illumination enjoys great popularity in spite of the fact that it restricts the microscopist to the use of rather expensive and delicate light sources. It is evident that uniform illumination within the entire field can only prevail if at least that part of the light source, the image of which fills the area under observation, is perfectly uniform. We shall see that most of the light sources in general use do not fulfill this requirement.

In view of the comparatively small fields to be considered in photomicrography we require light sources of high intrinsic intensity. Their total candle power is of no significance. This will become evident if we compare two light sources of the same total candle power but of different size. Let us assume that the area of one is five times as large as that of the other. Naturally the intrinsic intensity of the first must be only one fifth of that of the second. Using the same condenser system, the area illuminated by one light source is five times as large as that of the other. If the smaller light source is still large enough to cover the field under observation, the larger one will fill a field five times too large with an intensity of only one-fifth of that obtainable with the smaller light source.

Therefore the best light sources are those of small area and high intrinsic intensity. Foremost among light sources with these properties we find the arclamp. However, the intensity within the area of the crater is far from uniform and therefore arclamps can hardly be used for truly critical illumination. Incandescent lamps with concentrated filament for low voltage and relatively high amperage have small areas and rather high intrinsic intensity. They are not very expensive and are convenient to use. For critical illumination they cannot be used because the image of the filament would appear in the field and render the intensity non-uniform.

There are two types of lamps which are suitable for critical illumination, viz.: the Point-o-lite lamp and the ribbon filament lamp. The former may be considered as an arclamp enclosed in a bulb. This lamp can only be used with direct current and requires an expensive and complicated rheostat mechanism. The bulb is quite expensive and delicate. We see that the optically ideal properties of the Point-o-lite lamp are accompanied by practical disadvantages.

Similar conditions exist for the ribbon filament lamp, though perhaps, not quite to the same extent. The ribbon filament lamp operates with 6 volts and 18 amperes. Wherever alternating current is available, this high amperage and low voltage may be obtained by use of a transformer.

Direct current makes the use of a transformer impossible so that we would have to draw from the house circuit as much as 18 amperes, wasting 94 per cent of the total energy by interposing a rheostat to absorb the difference between 110 and 6 volts. Even with alternating current the lamp is not particularly practical because the bulb as well as the transformer are rather expensive and the former is delicate. These two lamps in other words, though acceptable for critical illumination have definite practical disadvantages.

Of course, if critical illumination were essential for good results in photomicrography, these disadvantages should not prevent us from using them. There are other methods of illumination known, which permit to obtain uniform illumination with non-uniform light sources. Many microscopists claim that these methods are objectionable for optical reasons of more involved nature.

This brings up the question: How can the methods of illumination influence the performance of the microscope? We know that the most important value of the microscope lies in its resolving power. The question can possibly be answered by studying the theories regarding the resolving power of the microscope. The highly complicated details of these theories would require another paper, especially in view of the fact that we could not restrict our efforts to the Abbe theory but would have to extend our study to the vast number of publications in defense of other theories which do not agree with the conclusions of Abbe and incidentally, seem to gain more and more in support.

This study, however, would lead us to the conclusion that neither the resolving power nor any other important part of the performance of the microscope, is influenced by the location of the intermediate image of the light source. We may, therefore, direct our attention to other methods which comply with the three rquirements and permit the use of non-uniform light sources.

"Koehler illumination,"[2] generally known as the method of forming an image of the light source in the plane of the rear lens of the objective, represents only one of many possible solutions of this problem under special consideration of the Abee theory.[3] Other principles have been uti-

[2] A. Koehler: *Zeitschr. f. wiss. Mikroskopie* V., 10, 1893, p. 433; v. 19, 1902, p. 417.

[3] Readers familiar with Abee's theory will know, that the formation of the image is explained as resulting from interferences due to diffraction of light by the structures

lized in photomicrography and micro projection. The reader will find an excellent analysis of the entire problem in two publications by M. Berek.[4] In view of the great practical importance of simple and efficient illumination systems, the reader may be interested in a description of their most essential parts and their performance.

The conditions for illumination of the field when an objective of comparatively high magnification is used, can be seen in figure 1.

In the diagram, the diameter of the field of view is indicated by the letters O_1–O_2. The objective of the microscope was included in the diagram in order to show that it forms another image of the light source in the plane of the rear lens. That this system permits to obtain uniform illumination irrespective of the structure of the light source may be rea-

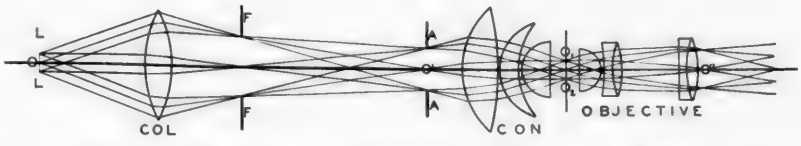

FIG. 1. ILLUMINATION SYSTEM FOR PHOTOMICROGRAPHY AT HIGH MAGNIFICATION (SMALL FIELD OF VIEW AND HIGH APERTURE)

The illumination system consist essentially of the following components: The light source *L*; a collector lens system *Col* which forms an image of the light source at a certain distance; a diaphagm *F* close to or in the focal plane of the collector; a diaphragm *A* in the plane where the image of the light source is formed; a condenser system *Con* at a certain distance from the diaphragm *A* approximately equal to the focal length of the condenser.

lized by following the passage of the rays coming from point *O*. The entire sector collected by the first lens system is concentrated in point *O'* and finally passes through the plane of the object as an almost parallel bundle of the width O_1–O_2. The same occurs with the sectors from other points of the light source. All parallel bundles have the same width and pass through the O_1-O_2 only their angle of inclination towards the

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of the object. In order that light from different points of the object may interfere it must be "coherent," meaning that it must originate in the same point of the light source. In other words, light from one point of the source must fill the entire field. Critical illumination however emphatically produces incoherent light inasmuch as each point of the field obtains light from a different point of the light source!

[4] M. Berek: *Zeitschr. f. wiss, Mikroskopie*, v. 40, 1923, p. 241–257.

M. Berek: *Sitzungsberichte der Gesellschaft zur Befoerderung der gesamten Naturwissenschaften zu Marburg*, v. 61, 1926, p. 251–282.

optical axis changes. In other words, the effective intensity of each point of the light source is uniformly distributed within the same area. No matter how irregular the structure of the light source, there will always be uniform intensity in the area O_1–O_2.

It should be noticed that the size of the light source has no influence upon the size of the illuminated field, because even light coming from one single point *O* illuminates the entire field. The light from the other points only increases the intensity and the angular aperture.

The same condition applies to the plane of the image of the light source where the iris diaphragm *A* is located. By opening or closing this iris diaphragm the size of the illuminated area is not affected but we can regulate the intensity by variation of the aperture. Iris diaphragm *A* is an aperture stop and a very important part of the illumination system.

At this point it may be mentioned that this system complies with the three requirements stated in the beginning.

As mentioned before, the objective converges the parallel bundles of rays to form another image of the light source and simultaneously of the diaphragm *A* in its rear focal plane which coincides fairly well with the plane of the rear lens. In the plane of this lens, diaphragm *A*, therefore, acts as a field stop.

When the aperture of the illumination is equal to that of the objective, the image of the light source will fill the entire rear lens of the objective. It is never beneficial and often harmful to the quality of the image and to the material of the object, to open the aperture diaphragm more than necessary to fill the rear lens with light. The excessive amount of light causes a haze, due to partial reflection by the lens systems of the objective and due to other reasons and this haze or "glare" greatly impairs the quality of the image. Furthermore the increased amount of light is naturally accompanied by stronger heat and thus damage to the object may result.

For the alignment of the illumination system, observation of the rear lens of the objective is very helpful. Viewing the image of the light source in this plane may also greatly facilitate the centering of the light source. When it is centered, its image must be symmetrically located in the rear lens of the objective. For this step of the alignment it is advisable to close the iris diaphragm *F*, the function of which will be discussed later.

We have seen that diaphragm *A* has a twofold action: it is a field stop in one plane and an aperture stop in another plane. Diaphragm *F* has

almost an identical function, the only difference being, that in those planes where diaphragm *A* is a field stop, diaphragm *F* is an aperture stop and vice versa.

This means that in the plane of the object, diaphragm *F* is a field stop and its image appears simultaneously with that of the object. This fact may be utilized for the centering of the condenser *Con.* Upon contracting diaphragm *F* its image must appear symmetrically in respect to the center of the field of view. After having centered the condenser, diaphragm *F* should not be opened further than necessary to reveal the entire field of view, because it would be in no way beneficial and may likewise produce glare or unnecessary heat to the object.

Thus, with the two diaphragms we may produce definite and unfailing criteria for the correct alignment of the illumination system.

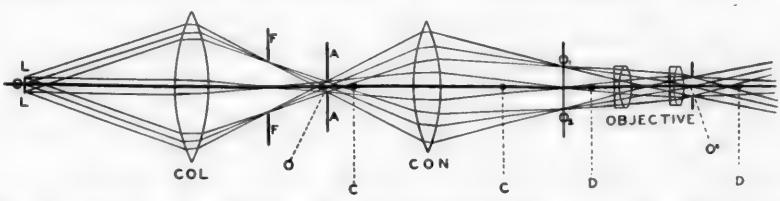

FIG. 2. ILLUMINATION SYSTEM FOR PHOTOMICROGRAPHY AT LOW MAGNIFICATION (LARGE FIELD OF VIEW AND LOW APERTURE)
C = focal points of the condenser *Con.* *D* = focal points of the objective.

At this point it may be mentioned, that diaphragms of this type can likewise be used for the alignment of an illumination system based on the principle of critical illumination. Field and aperture diaphragms are essential components of any illumination system.

In spite of these devices it is not always easy to make the alignment. Difficulties may be encountered especially when taking photomicrographs at low magnifications. Then the size of the field becomes so large and the numerical aperture so small, that the ordinary condenser system of the microscope can no longer be used. If condensers of longer focal lengths are used, the substage diaphragm of the microscope is no more at the correct place to act as an aperture stop. Furthermore, the image of the light source should not appear in the rear focal plane of the objective but closer to its optical center. These conditions are diagramatically shown in figure 2. When tracing the rays coming from one point of the light source we see that they pass through the plane of the

object, not as a parallel but as a convergent bundle. Consequently the image of the light source is not formed in the rear focal plane *D* of the objective but closer to its optical center. It is evident that in this case the aperture diaphragm *A* should no longer be in the focal plane of the condenser but farther away from it.

An optically correct illumination system therefore should permit displacement of the diaphragm *A* in the direction of the optical axis. In order to be able to align the illumination system correctly for every possible magnification, we therefore still have to solve the problem of how to find the correct place for this diaphragm when photographing at lower magnifications. To give general suggestions for this part of the alignment is somewhat difficult and may be unnecessarily confusing because various manufacturers use slightly different methods. However, the reader will find explicit directions issued by the manufacturers of his equipment.

We have seen that although the means available for the control of the alignment of the illumination system are not as simple as those for the control of the focusing of the microscope, there really are definite and unfailing criteria which permit us to determine whether correct illumination prevails. The microscopist should always avail himself of these criteria rather than try to make adjustments without any definite plan.

STEREOPHOTOMICROGRAPHY*

E. J. ROY

From the Kankakee X-Ray and Clinical Laboratories, Kankakee, Illinois

Adding the third dimension to a photomicrograph will give valuable information which can be secured by no other means. An otherwise drab photograph immediately blossoms with unsuspected detail under the revealing lenses of the stereoscope. Perhaps the word micro should be used advisedly in connection with this paper as the magnifications used did not exceed fifty diameters.

The apparatus required is simple and may be home constructed. Any good camera on a rigid support which may be tilted down a few degrees;

*Received for publication, January 21, 1933.

a 30-mm., 16-mm. and 8-mm. lens (microscope objectives for the last two named); a suitable lighting arrangement and a small turn table are all that is necessary. The principle on which the method operates is simple as determined by the rotation of the subject thru a predetermined distance and the making of the two views at each respective angle. Many trials have shown that a changing of the angle from $2\frac{1}{2}$ to 3 degrees gives the best results.

Comparatively flat lighting must be used as shadows have a perplexing stereo effect. Reflections are another source of trouble and should be eliminated if possible. The author uses a graflex $3\frac{1}{4}$ x $4\frac{1}{4}$ and an improvised mount for the small lenses. The illuminant is a ring of flashlight bulbs that are battery operated. However, a transformer can supply the correct voltage for the flashlight bulbs where alternating current is used, or a reostat when direct current is used. These methods will give a uniform voltage and have the advantage over the ever weakening battery current. A Silverman opaque illuminator would be the thing to use in this connection, but they are rather costly.

A little cone made of black paper should be fitted to the lens to keep direct light from reaching it. If the chromatic correction of the lens is poor a green monochromatic filter over the stop will make a remarkable difference in detail, however, color rendition will in this case be spoiled. Focusing should be done with the lens wide open and the filter in place. Before making exposures the diaphragm should be closed to a pin point.

Sufficient depth of focus is often hard to obtain. It is this factor which limits the practicable magnification in micro-stereoscopic work as the higher power objectives have progressively less focal depth. It is obvious that as stereoscopy is a method by which the different planes in a subject are revealed, zero focal depth could only mean one plane and one plane of course would give a flat picture.

Figure 1 gives the details of the layout which probably can be immensely improved upon. The little turn table, upon which the specimen rests, should be rigid; the bearing should have absolutely no play in it. The photograph presented with this paper was made with a 30 mm. cine objective on super-sensitive panchromatic film. The exposure was about 1 minute without filter and 6 minutes with it. One exposure is made in any desired position, then the table rotated 2 to 3 degrees and the other made. Direction of rotation is unimportant as the finished prints are oriented on the mount by trial.

Where higher powers are sought the mechanical requirements will of course be severe and beyond the crude arrangement in the illustration.

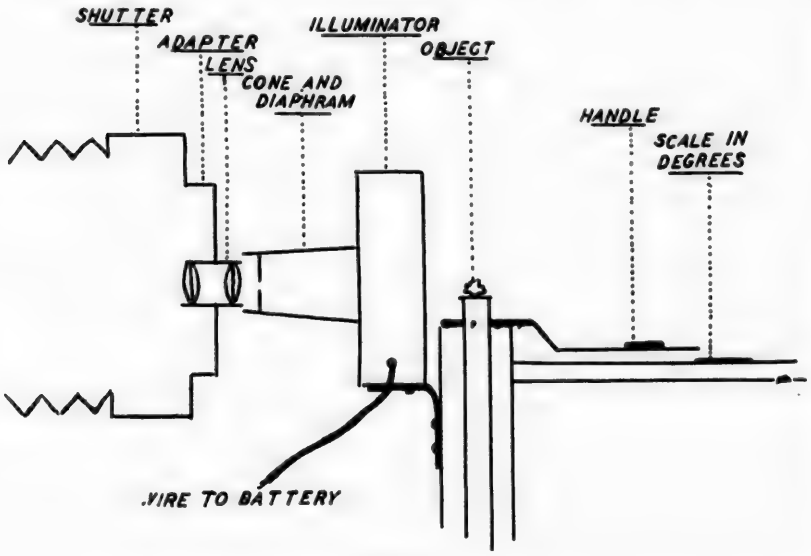

FIG. 1

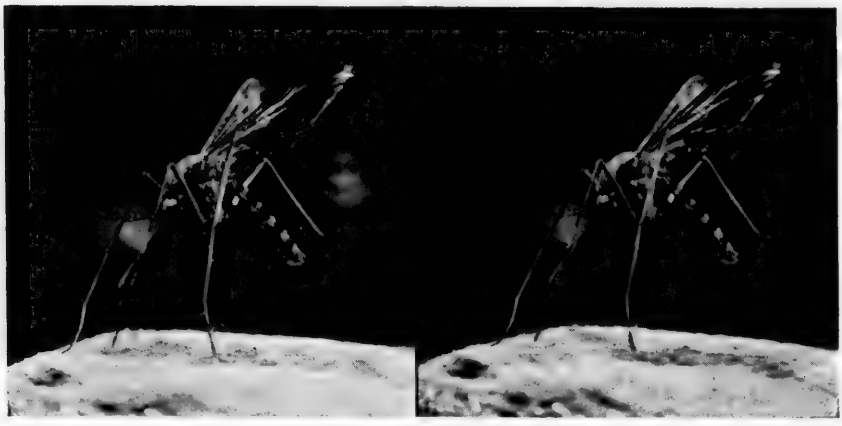

FIG. 2

Using the 4-mm. objective the working distance is so small and focusing so critical that an optical bench becomes almost a necessity.

The object must be mounted in the "pivotal plane" with optical precision or the rotation will carry it beyond focal depth or perhaps out of the field of view. The object must be the pivot. Any change in the specimen between or during exposures must be guarded against. Expansion, drying out, moisture absorption, etc. are sources of failure. In this work all the precepts for good photomicrography by reflected light apply with increased force.

PHOTOGRAPHIC TECHNIC, NEW PROCESSES AND EQUIPMENT*

F. R. HARDING

From the Photographic Department, Children's Hospital, Boston, Massachusetts

PHOTOGRAPHY OF THE ORAL CAVITY

One of the most difficult assignments in clinical photography is that of the oral cavity.

The method described below will generally give good results provided there is complete coöperation of the patient. Patients under five years of age will not coöperate as they cannot be made to understand what is being done.

No mechanical methods of mouth stretching or tongue depressing are used as they usually alarm the patient. This does not hold true in adult patients.

Place the patient in a chair with an adjustable head rest if possible; otherwise use an ordinary chair with a back. Tip the patient's head to the rear until it rests on the chair back or head rest. Use a 1000-watt lamp behind the chair, with the reflector of the lamp from one to two feet above and to the rear of the patient's head, facing the camera. Set the camera in front of the patient, tilted to as near the angle of the head as possible. Now have the nurse or attendant hold a head mirror (found in all nose and throat trays) against the lens board and as close to the lens as possible. Reflect the rays of the lamp from the mirror into the mouth. A head mirror is used because of its curved shape, which concentrates the rays of light into a small beam. An ordinary flat mirror is

* Received for Publication April 24, 1933.

unsatisfactory for this purpose. Focus the camera as usual. Make the exposure on the fastest film available, such as Eastman Supersensitive Panchromatic. An exposure of $\frac{1}{10}$ second at stop F:8 with this film gives satisfactory results.

Anything that can be seen in the mouth, such as cleft palates and tonsils can be photographed in this way. Both motion pictures and color

FIG. 1

plates have been made by this method of illumination. This method requires no outlay for new apparatus, furthermore it is very simple to set up. No fogging of the negative, due to the camera facing the light source, has ever been observed. The light is much higher than the lens, which is pointed downward. Close up views of the oral cavity made by direct, instead of reflected, artificial light show a bad shadow more than half way across the mouth. This is because the camera is very close to the mouth, and the impossibility of centering the light. Care should

be taken in photographing cleft palates, not to allow the teeth to cut off the view of the top of the cleft.

BACKGROUNDS FOR PATHOLOGICAL SPECIMENS

The selection of a proper background for photographing gross pathological specimens is often very difficult. The methods described have all been used and are giving satisfaction to the users at the present time.

To get a clear white background proceed as follows. Construct a light box about 18 inches square and about two feet deep in the bottom of which is placed a 500-watt bulb or four 100-watt bulbs. Six inches down from the top of the box a square sheet of ground glass is placed to diffuse the light from the bulb or bulbs. On top of the box a square sheet of flashed opal glass is placed which completes the diffusion of the light in the bottom of the box.

The specimen is placed on the opal glass and photographed with the usual illumination. During the regular exposure the bulb or bulbs in the box are switched on long enough to register the proper density for a white background on the film. Some experimenting will be necessary to get the proper balance of exposures for background and specimen. Using this method there are no shadows cast on the background by the specimen. Another method of obtaining a white background is to use a white enamel tray. After the specimen has been dried on the surface place it on the tray. (If the surface is not dried reflections will appear where the surface is wet.) Place the tray on the floor, with the camera directly over it. Use a tilting head on the tripod, if no regular vertical camera is available. Place the lights at each side of the tray and as nearly over it as the camera will allow. This method will usually give a slight shadow on each side of the specimen. The background will be white.

If the negative is properly developed and the print does not show a clear white background, the developer used may not have had sufficient contrast. For developing the negative a good Metol-Hydroquinone developing formula should be used, rather than one compounded of Pyro, which is a soft working developer more suited for portraiture.

If the specimen cannot be dried off it can be photographed under water or saline solution. The choice of the liquid to be used is left for the pathological laboratory technician to decide upon.

Use black paper in the bottom of the tray if a black background is

desired. Be sure the paper is black as most black paper is really a very dark gray. A suitable paper to use is that which is folded over individual X-Ray films. This paper makes a very fine black ground especially for use with specimens photographed under fluid. The dye will not leave the paper.

A third way is an adaption of the tray method. A piece of white paper and a piece of black paper are laid together and then placed between two pieces of clear glass. This "sandwich" is bound together on all sides with adhesive tape. If a white background is not wanted the glass is turned over to the black side. One disadvantage found in this method is that the black side sometimes shows a reflection of bright metal fixtures on the front of the camera.

Fresh specimens offer a problem not met with in prepared subjects. They cannot be easily photographed under fluid, as blood oozes from the cut surface of the specimen and mixes with the liquid in which the subject is immersed. The use of saline solution prevents any great quantity of blood escaping from the subject but enough comes out to color the liquid a pale red brown. When this is photographed, it produces a general lack of contrast which resembles a fogged negative. If the fresh specimen is photographed on a dry tray, there are usually many reflections. These reflections cannot be avoided but trying different combination of lights will often reduce them very much. The dry tray method for photographing fresh specimens seems to be the most satisfactory at present.

Two very good papers on the lighting of pathological specimens were published in the December 1932 issue of this JOURNAL.

PRESERVATION AND RESTORATION OF MOTION PICTURE FILM

The problem of caring for motion picture film confronts all biological photographers. Film stored in open racks or humidors not properly cared for soon becomes brittle and will not always run through a projector without breaking. One method of restoring flexibility to the film is as follows: place a solution of glycerine and water in a large container such as a waste barrel. The depth of the solution should be about one inch. About an inch above the liquid, a wire screen is suspended. The film should be unrolled and placed in the barrel, the screen acting as a guard to prevent the film from coming into actual contact with the solution.

There is a commercial system that processes the film so that it retains its flexibility. The film must be sent to a special laboratory for this purpose. This process not only makes the film flexible, thus insuring a longer life, it also makes the film scratch proof. A great many valuable films are being given this treatment. The price for this proccess varies from $6.00 to $8.00 for 16-mm. film and proportionately higher for 35-mm. film.

To restore films that are not badly dried out the ordinary humidor can with its disc of felt or absorbent paper moistened with a solution of one part glycerine to five parts water can be used. From two to five days should be sufficient to restore flexibility.

Commercial motion picture laboratories have tried out a great number of formulas for clearing and restoring flexibility to film. They consider Tri-chlorethylene the best for this purpose. This chemical removes dirt and grease from the film and at the same time restores the original flexibility. It does not harm the film. Tri-chlorethylene can be purchased from most chemical supply companies.

TO HOLD BACK CHEMICAL REDUCTION WITH RUBBER CEMENT

Rubber cement may be painted over any area of a negative or positive to prevent chemical reduction of that area. For example, when it is necessary to preserve the lettering that has been done on the clear white border of a print, it can be done in the following manner.

Figure 1 shows a copy of an old print. Rubber cement was applied over the picture in the oval. Care was taken to see that the entire surface of this oval was covered, otherwise streaks would have been apt to show after the reduction process. After the oval was carefully covered, the print was placed in a weak solution of potassium ferricyanide and hypo long enough to reduce the grayness from the border, leaving the letters clear and sharp and producing no effect on the picture itself. (This is the well known Farmers Reducer. It should be pale yellow, not orange, and should be used weak rather than strong.) In this particular case, there were letters at the top of the oval which were matted out with black paper on the negative.

As soon as the reduction had been carried to the desired point, the print was removed from the reducer, washed for a few seconds and placed in the fixing bath, which completely stops the chemical action of the reducing

agent. The fixing bath also removes all traces of yellowness from the print.

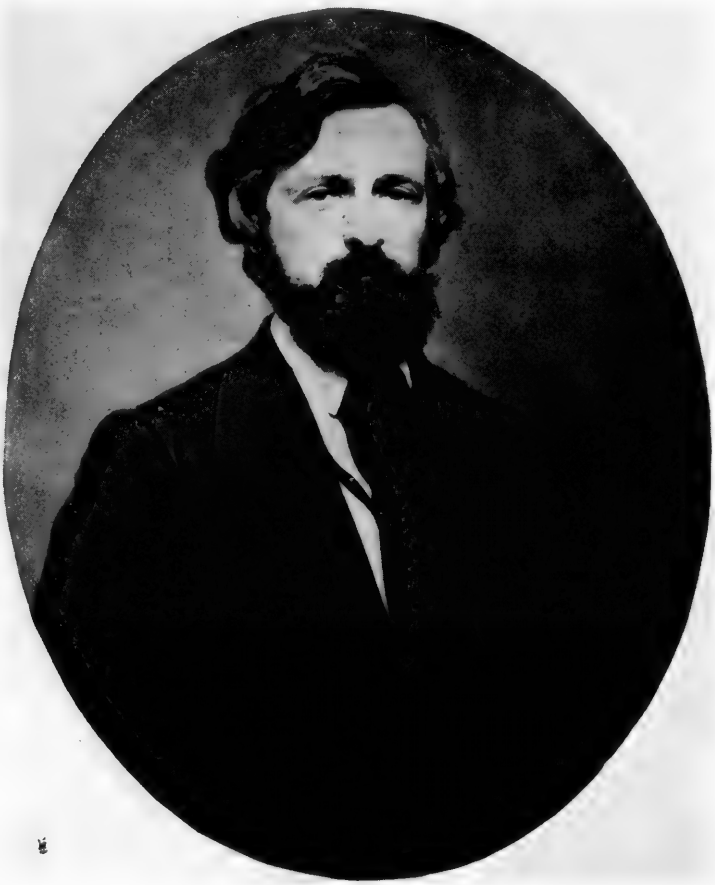

FIG. 2

RUBBER CEMENT

Rubber cement is taking the place of paste, mucilage and glue. It does not warp, shrink, curl or stain paper, cardboard or muslin. It is the only adhesive which will permanently hold these materials to metal.

No muddy background remains after cement is applied. The natural color of the paper is unchanged. It may be applied with a brush, spreads

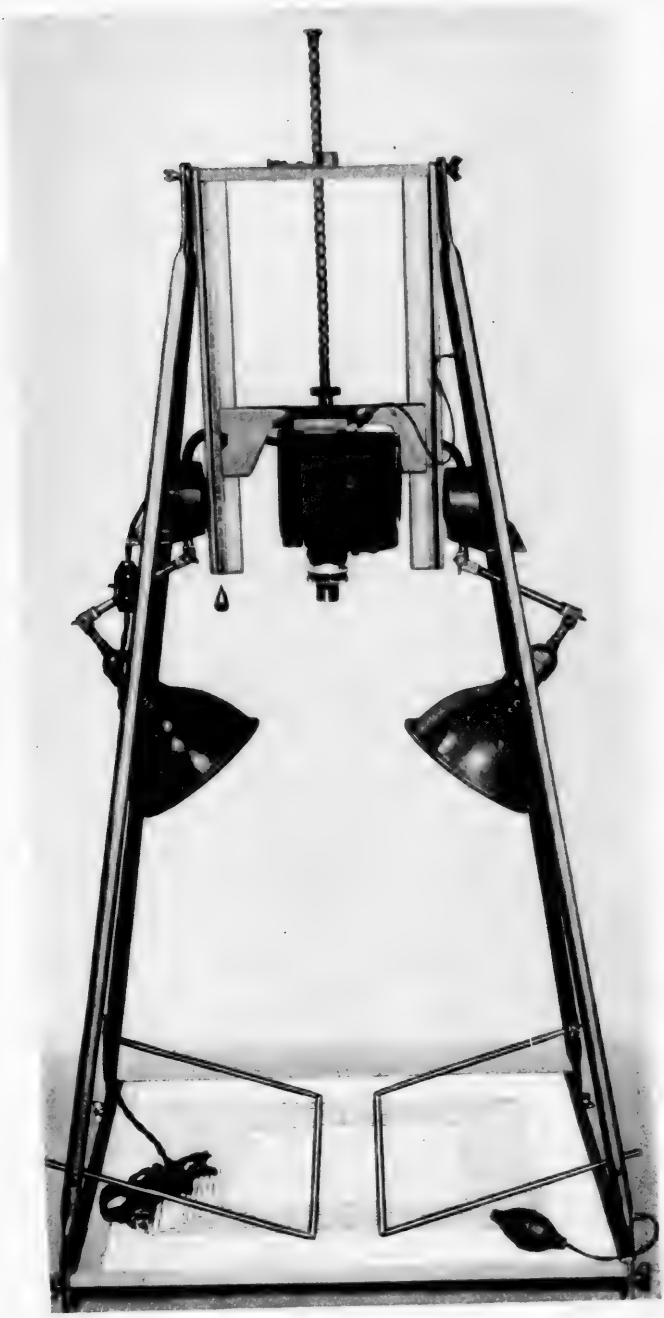

FIG. 3

evenly, remains permanent and pliable, and dries quickly. The dried cement, where not desired, may be rubbed off with the finger, leaving no mark.

This cement can be made by dissolving a small amount of caoutchouc, which is raw, unvulcanized rubber, in benzine. It takes a few hours to dissolve. The cement seems to work best at the consistency of thin syrup.

ANIMATION STAND

The Bell and Howell Co. has placed on the market an Animation Stand which provides a self contained unit for making on 35-mm. film, animated drawings, maps, film slide negatives, titles etc.

The stand consists of a B & H Eyemo spring driven 35 mm. camera, a supporting stand, a mount for the camera, which can be raised or lowered; two photoflood lamp reflectors, a single frame exposure trigger, and provision for centering and framing the subject. Further information about the Animation Stand can be had from Bell and Howell Co., Chicago, Illinois.

REDUCTION IN PRICE OF SAFETY X-RAY FILM

The Eastman Kodak Company announces that the price of Safety X-Ray film has been reduced to the price of nitrate film. With the price for both kinds of film the same, there is no longer any need for institutions to continue the use of the highly inflammable nitrate film.

A number of disastrous fires in the past few years have been caused by nitrate film.

With the last barrier down, that of price, the old style film should soon disappear from the market. The reduction in price applies only to Safety X-Ray film.

THE NEW CINÉ-KODAK SPECIAL

The Ciné-Kodak Special, a 16-mm. motion picture camera that will "do everything" and then a few tricks more, has been announced by the Eastman Kodak Company.

This camera was introduced because of the Eastman Kodak Company's belief that 10 years of amateur cinematography have prepared the way for a 16-mm. camera of maximum versatility. The appeal of the new camera will probably be to advanced amateur movie makers,

to motion picture clubs, to engineers, to manufacturers, to doctors, to laboratory technicians—classes of cinematographers having use for 16-mm. equipment with a professional camera's range of abilities.

The basic model incorporates provisions for double or multiple exposure, dissolves, slow motion, fades, masking, interchangeable film

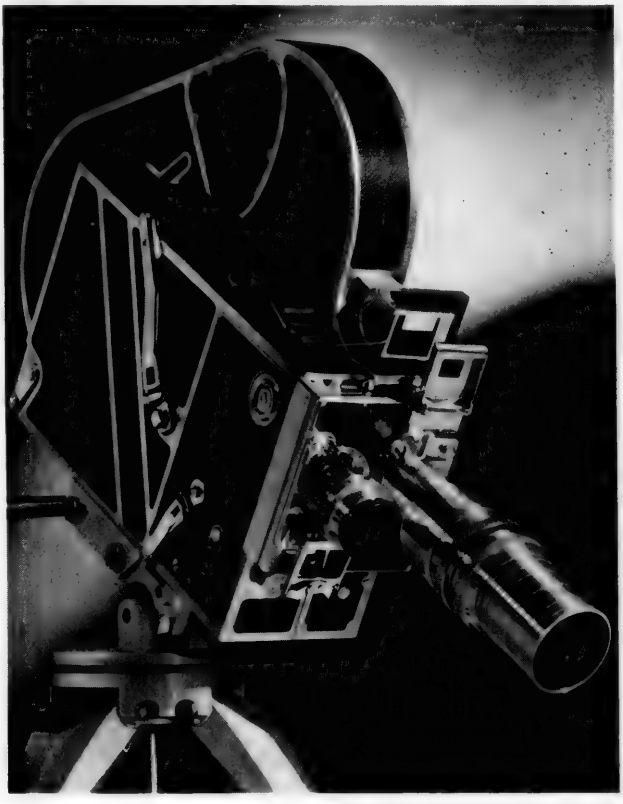

FIG. 4

chambers, variable speed, and framing and focussing through the main lens system of the camera. It has a variable shutter, a two-lens turret, and provision for either spring motor drive, hand cranking, or the attachment of an electric motor drive. In addition to these features of the basic model, additional equipment or alterations will on special order be applied to the camera in process of manufacture.

With the advent of this camera, viewers of amateur motion picture film may no longer be surprised to see one person appearing in several places at once on the screen, to see all the possible tricks of dissolving and fading and appearance from nowhere, to see Niagara Falls slowing down or speeding up at will instead of maintaining its accustomed rate of fall, to

FIG. 5

FIG. 6

see a "long shot" dissolve into a close-up at a swing of the turret, to see all types of "animation," including the appearance of animated subjects in the same scenes with living subjects, to see scenes interestingly masked, to see a man's legs walk out from under him, to see many slow motion effects, to see—as the Ciné-Kodak Special can record it—large views of very small subjects that were only an inch or two from the camera.

Such pictures represent the Ciné-Kodak Special's trick possibilities. The same abilities, however, are applicable also when the camera is used in technology, in the analysis of athletic form, and in other "serious" ways.

How are these various tricks and refinements accomplished? The following catalog of the Ciné-Kodak Special's features will show.

1. Fades are made possible by the camera's variable shutter. This shutter may be adjusted to full opening, one-half, or one-quarter, or closed. The ability to effect these changes while the camera is running makes fades, in or out, possible.

2. Lap dissolves (the overlapping of two fades) are made possible by use of the variable shutter together with the ability of the camera to wind back the film for a second exposure.

3. Double or multiple exposures are possible because the film can be wound back.

4. Interchangeable chambers, of 100-foot or 200-foot capacity, make it easy to shift at any time from one type of film to another. Without finishing out a roll, it is possible to change in a moment from panchromatic to Kodacolor or to super-sensitive panchromatic by substituting a chamber loaded with the other type of film. The ability to expose 200 feet of film continuously is also a marked advantage. The chambers are interchangeable without fogging even one frame of film.

5. A positively-acting mechanism for making single pictures permits animation, laboratory "growth studies," speeded-action scenes, and various tricks.

6. A separate single-picture shaft for an electric motor drive is useful for time and growth studies, or for experimental sound work. Another shaft permits the connection of an electric motor to the camera for continuous operation.

7. The Ciné-Kodak Special has a slot for the insertion of masks, and a set of simple masks will be supplied with the camera. Circular masks, oval masks, and others of more elaborate shapes, are useful for certain desired effects on the screen.

8. Half-masks, which block out one side of the film or the other, permit the same person to appear twice in one picture when the winding-back feature is used to produce a double exposure on a single length of film. Animated and human subjects, as a matter of fact, can thus appear together in one scene. By the use of horizontal half masks the bottom or the top of the picture similarly may be blanked out.

9. A great variety of tricks and stunts are made possible by combinations of masks, dissolves, and reversing, for double, triple and multiple exposures.

10. Almost 40 feet of film can be "shot" at a winding. An audible signal warns when the spring is nearly wound and when it is nearly run down.

11. The hand-cranking feature of the camera permits the filming to be carried on when the spring motor runs down, thus letting an entire film be shot without stopping.

12. The Ciné-Kodak Special possesses a turret head for two lenses. Lenses are quickly interchangeable on the turret head, which will accommodate the various lenses that are available for the Ciné-Kodak Special.

13. A reflex finder, which cuts in on the main lens system of the camera, thus shows the image actually formed by the taking lens. By the use of this finder, both the exact picture field and the precise focus may be obtained, even in such extreme closeup position as when the camera is only an inch or two from the object to be photographed. Such an extreme close-up necessitates the use of proper supplementary lenses. Backed film as well as clear-base film can be used without hindering this finder's operation.

14. The camera is also equipped with the usual direct view finder.

15. The speeds of the Ciné-Kodak Special range from 8 to 64 frames a second, in the following gradations: 8, 16, 24, 32, 64.

16. There is a cushioned stopping mechanism for high speeds.

17. There are two film meters: one, governed by the diameter of the roll of film, is for indication of the footage left for exposure in the film chamber; the other, geared and marked in individual feet, is intended as a guide in connection with the winding-back feature.

18. The variable shutter is useful not only for fades and dissolves but also as an additional exposure control. It is valuable for producing sharp images of fast-moving objects. It can be used in place of a neutral density filter to cut down the light in Kodacolor filming.

19. Several safety features prevent many mistakes and make operation as simple as possible.

The engineers who designed the Ciné-Kodak Special consider its most important innovations perhaps to be: the eight-frame shaft (moving the film eight frames to one turn of the crank, for winding back or for hand cranking); the one-frame shaft (for special single-frame work, such as growth studies or for driving the camera in synchronism with experi-

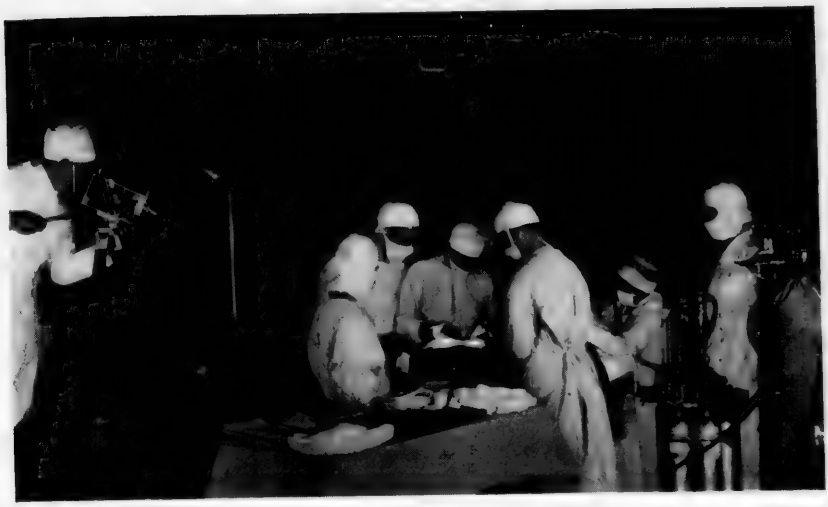

FIG. 7

FIG. 8

mental laboratory equipment); the variable shutter; the removable film chamber; and the reflex finder.

Simultaneously with the Ciné-Kodak Special, the Ciné-Kodak Tripod will become available, designed for the Special but useful also for other 16-millimeter cameras and still cameras. Unusually light in weight and compact, it is extremely rigid and easy to adjust. Horizontal, vertical, and diagonal panorams can be made with it. Furthermore, a motion picture camera attached to the Ciné-Kodak Tripod can be pointed straight up or straight down—a tripod feature not ordinarily found.

Although essentially a tripod-operated camera, the Special can be hand held for the making of many shots. The Ciné-Kodak Special is not, however, intended for the requirements of every-day movie making. The other Ciné-Kodaks of the Eastman line are considered sufficiently versatile to meet the requirements of all but those amateur cinematographers or experimenters who wish to specialize in some type of advanced cinematography.

A 1-inch f. 1. 9 Kodak Anastigmat lens will be supplied with the Ciné-Kodak Special unless a special order indicates that the substitution of another lens is desired. In addition to this lens, others directly available are the 15-mm. f. 2.7 wide-angle lens, the 2-inch f. 3.5 lens, and the 3-inch, $4\frac{1}{2}$-inch, and 6-inch telephoto lenses. Other desired focal lengths can be adapted to the Special.

Photographic History

Theories of the past become realities of the present and mentors of the future

FROM PHOTOCHRONOGRAPHY AND BIOTACHYGRAPHY TO CINEPHOTOMICROGRAPHY*

OSCAR W. RICHARDS

From the Osborn Zoölogical Laboratory, Yale University

The biologist owes the first suggestion that photography could be used to analyze the motions of living things to the astronomers. In 1849 Faye tried to use the images on a plate to fix the movement of a star as it passed a meridian. Onimus and Martin recorded the heart beat on a wet collodion plate in 1865 and used the picture to show the difference in size and shape of the relaxed and contracted heart. During this time and for the next few years there were many projects patented but little seems to have been done with them either photographically or biologically.[1]

The first successful use of this method was accomplished by Janssen who photographed the passage of Venus over the Sun in 1874 at intervals of 70 seconds with the astronomical revolver. Four years later[2] he suggested that this automatic method could be used by the biologists to analyze the motion of animals.

About this time Muybridge, of San Francisco, was photographing the movements of horses for Governor Stanford and of other animals with a series of cameras arranged in a row parallel to the path of the animal. A background was provided with a coördinate grid painted on it and as the animal ran along in front of this background it successively broke wires

* Received for publication February 13, 1933.

[1] For details cf. chapter 5 of Coissac (1925). The Daguerreotype used by Faye was too slow to give successful exposures.

[2] Marey (1894) attributes this to 1878 although the reference in the footnote on p. 104 is actually 1876. The Journal referred to was not available so that I was not able to verify either date.

which tripped the electromagnetic shutters of the battery of twelve to forty cameras. The first photographs were obtained with the wet plate process and the position of the animal was measured on each plate with respect to the part of the grid it was over at the time of exposure. The first pictures were taken about 1870 and by 1889 the pictures were arranged around a glass disc so that the image could be projected successively on a screen with the aid of oxyacetylene lamp and a lens. This apparatus was called by Muybridge the Zoöpraxiscope and the projections were primitive motion pictures. Thus he is considered by many to be the grandfather of motion pictures. The then. new gelatine-silver bromide emulsion became available so that his later pictures were much better. Anschutz also used the same method and obtained superior results.

FIG. 1. PHOTOCHRONOGRAPH OF A WHITE DUCK IN FLIGHT
From Marey (1901)

However, the pictures were not taken at equal intervals of time because the speed of the animal varied during the course and further the pictures were not taken from the same view point but as if the spectator ran along the row of cameras. For these reasons the pictures were not entirely satisfactory for the biological analysis of the movement.

The problem of taking the pictures at equal intervals of time was solved by Marey in 1882 by placing a revolving shutter into the camera so that a picture would be taken every hundredth of a second. The analysis of the photographs, made on the same plate, was facilitated by recording in addition the image of a rule and a watch on the plate (fig. 1). The same year Marey improved the revolver as a gun so that the pictures of the flight of birds could be made easily from the same viewpoint.

In fact the early development of cinephotography and of cinephotomicrography was mainly due to its use by Marey (fig. 2) in his remarkable

investigations of the movement of living organisms. Marey was born at Côte-d'Or, France, on March 5th, 1830. He studied medicine, perfected the sphygmomanometer and obtained his degree in 1854 with a thesis on the circulation of the blood. He then became interested in the use of graphic methods in physiology and used tambours and Ludwig's

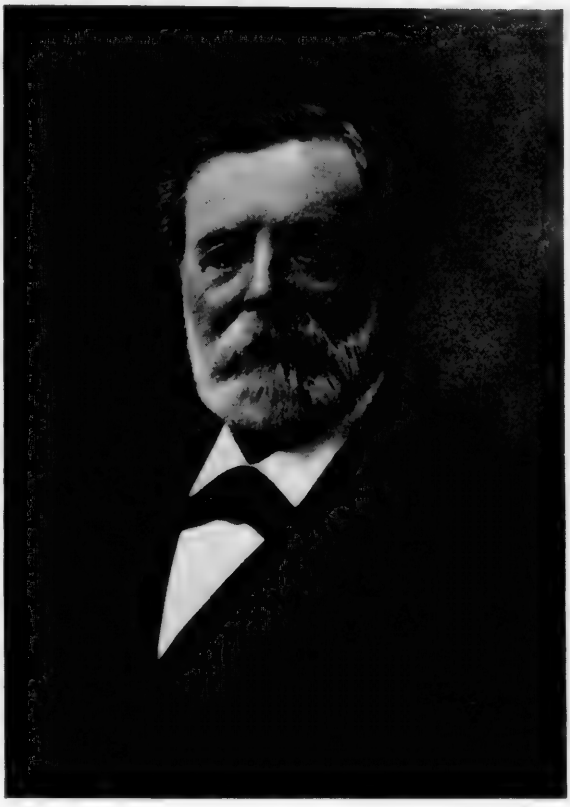

FIG. 2. ÉTIENNE JULES MAREY
From the *Lancet* (1904)

kymograph to record the movements of the wings of birds. He duplicated these recordings with complimentary mechanical models to synthesize the movements. These methods were cumbersome and the advantages of the optical lever and of photography soon attracted his attention and he spent the rest of his life using and improving them in his studies of

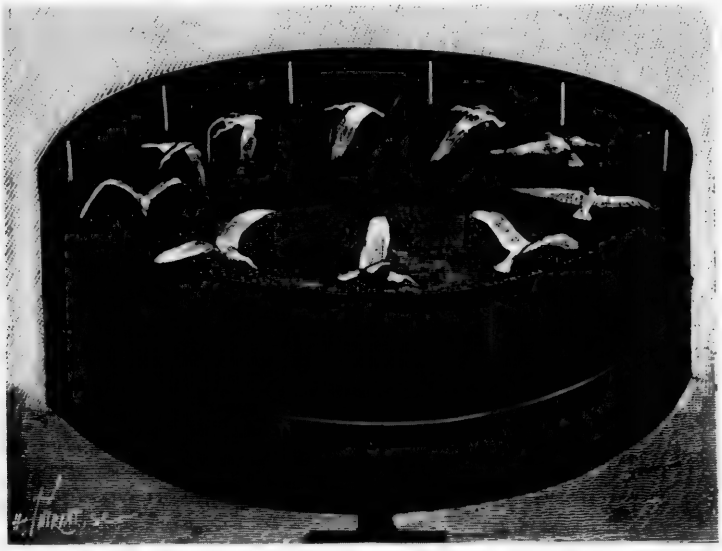

FIG. 3. ZOÖTROPE ARRANGED TO SHOW BIRD FLIGHT
From Marey (1894)

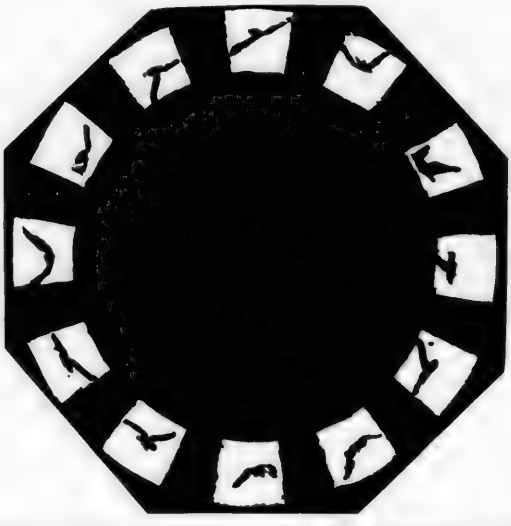

FIG. 4. PLATE EXPOSED IN THE PHOTOGRAPHIC GUN
From Marey (1894)

animal locomotion. This was done first at the College of France where he became Professor of the Natural History of Organized Beings in 1867 and later at the *Institute de Marey* given to him by the French Government. These studies were continued after his death on May 15th, 1904, by his students.

The early studies of 1882 contain discussions of the fact that black often reflects and appears incompletely black in the finished photograph. Con-

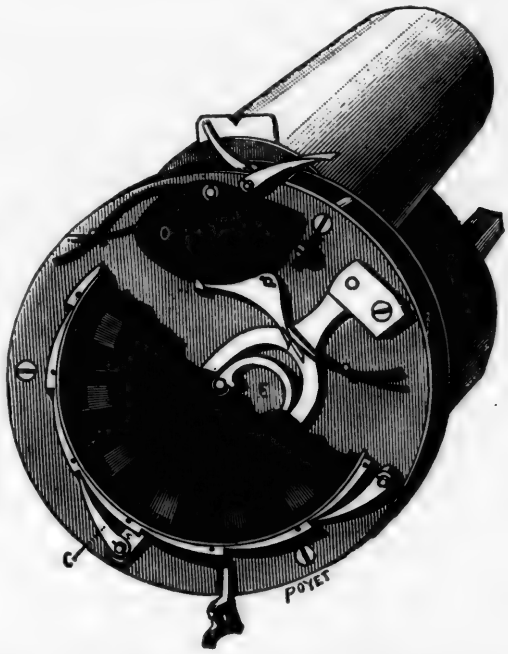

FIG. 5. DETAIL OF THE MECHANISM OF THE PHOTOGRAPHIC GUN WHICH WAS MOUNTED ON A GUN STOCK AND RESEMBLED A SHOT GUN
From Marey (1894)

trast was obtained by the use of white animals or of men dressed in white. Chevreuil, distinguished collaborator of Marey, solved the problem of partial reflection of black backgrounds by having box-like houses built with one side open, without windows and with the inside blackened. This gave a dead black background and the animal was photographed as it passed in front of the black cavity. Two of these were then placed at right angles, a camera faced each and a third camera was mounted in

the air over and facing a black background on the ground. Thus it was possible to take three pictures simultaneously from three mutually perpendicular viewpoints of the organism as it passed these black cavities. The successive position of the parts of a bird during flight could be determined from the three plates and bronze reconstructions were made to show the analysis of the movements of flight. The Zoötrope (fig. 3) was also used to show models in succession to the eye in a manner simulating motion pictures.

To study the flight of birds more easily Marey improved the revolver and built it as a gun. Twelve pictures could be taken on a revolving octagonal plate (fig. 4), within a second. The exposure was determined by a rotating shutter (fig. 5), and was usually $\frac{1}{700}$ second but with good sun it could be reduced to $\frac{1}{1500}$ second. As the bird flew away it gradually got out of focus. Londe and Sebert constructed a gun with multiple lenses to avoid this difficulty but the plan proved to be too costly for practical use. A camera with twelve lenses arranged in two rows was used also to photograph a moving object giving successive images on the same plate. The electromagnetic shutters and other accessory apparatus made it unwieldly and too expensive for general use.

When a single plate was used the movement of the subject was not always great enough to separate the images sufficiently for their analysis. Since it proved impractical to move the bulky camera, the camera was pointed at right angles to the subject and a revolving mirror reflected the light to the camera. The mirror could be moved uniformly at whatever speed was necessary to properly space the images on the plate. Moving plate holders were used but plates long enough for an adequate number of exposures were unsatisfactory owing to the inertia of the heavy plate jarring the apparatus when its motion was stopped for the duration of the exposure.

The use of sensitized paper in rolls stimulated Marey to invent a mechanism which would move the film along as one turned a crank. The sensitive material had to be at rest during the time of the exposure to avoid blurring, even with very brief exposures, which necessitated an intermittent movement. By 1888 this mechanism was placed in a light tight box (fig. 6), which could be attached to the camera, although at first the equipment was used in a dark room with the lens of the camera passing out through the wall. Daylight loading spools were made by placing a length of opaque paper on each end of the sensitive material.

Flexible film was made available by Eastman in 1889 with a more rapid emulsion on a suitable transparent base. The control of the movement by clockwork completed this stage in the development of the equipment.

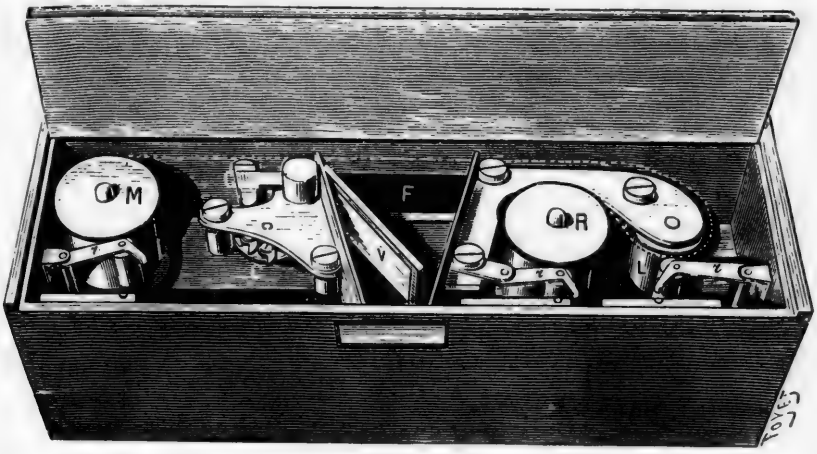

FIG. 6. FILM CHAMBER AND MECHANISM OF MAREY'S (1894) PHOTOCHRONOGRAPH
F is the opening toward lens

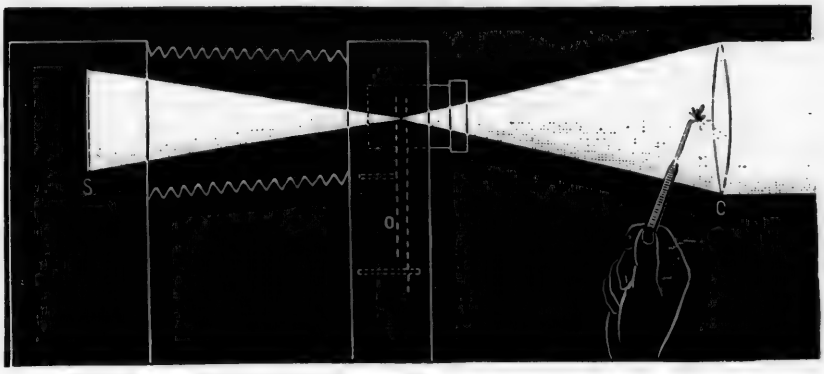

FIG. 7. ARRANGEMENT USED TO PHOTOGRAPH THE FLIGHT OF INSECTS
From Marey (1891)

In 1891 Marey published his first general description of the equipment and stressed its importance for the analysis of motion whether it be the generating line of a geometrical figure, the trajectory of a falling body, or the movement of man himself. For the latter the humans were clothed

in black and a strip of silver braid sewed along the leg or other part, the motions of which were to be studied by photochronography. This proved more satisfactory than the use of black backgrounds. The same year Marey published some beautifully sharp pictures of an insect in flight, taken with the arrangement shown in figure 7. The duration of the exposure was $\frac{1}{25,000}$ of a second. The light was furnished by the sun reflected to the camera with a heliostat and the exposure was controlled by a rotating shutter. He stated here that the condenser should have a focal length of twice that of the camera lens.

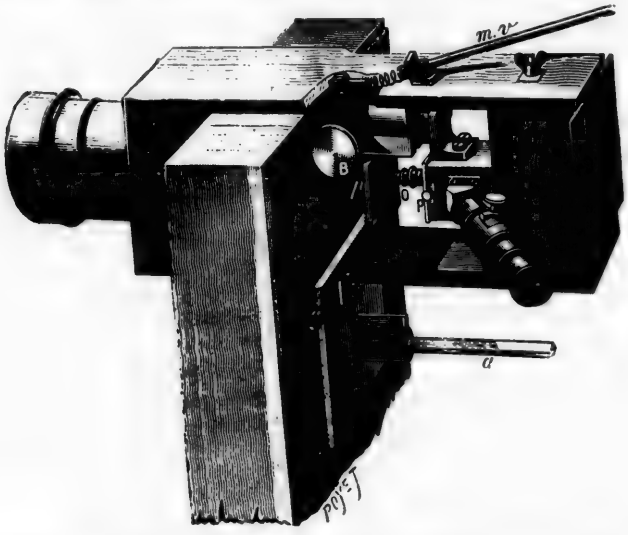

FIG. 8. THE SPECIAL MICROSCOPE USED BY MAREY (1894) WITH THE FILM CHAMBER OF FIGURE 6

O the objective, *p* the slide holding the subject and *P* is the movable prism used when focusing.

Demeney, a student of Marey's, made a picture of a person saying the words "*je vous aime*" in 1891 and arranged the pictures on the periphery of a disc so that they could be viewed in sequence through a slit as the disc was revolved. The movements were clear enough for a deaf person to recognize the words from a knowledge of lip reading and the machine was called a Phonoscope. He showed these to the public in 1892 using a projector containing an oxyacetylene lamp. Later he and Marichelle used such outfits to teach the lip reading to the deaf which presaged the use of films in teaching.

During a meeting in 1894 the mathematicians of the French Academy were requested to explain why the cat always lands on its feet when it is dropped, but the answer came out of Marey's pocket in the form of photographs of a white cat taken at 60 per second. These were shown in the zoötrope (fig. 3) at ten per second which demonstrated that a small movement of one paw gave sufficient inertia to effect the turn of the cat.

Marey published descriptions of his apparatus and the results of the analysis of the pictures in his book on movement in 1894. This was translated into English in 1895. Marey describes here the use of the apparatus to record the beating heart and the application of his photochronographic apparatus to the microscope. Sunlight was used as a light source reflected to the condensing lens by a heliostat. Figure 8 shows the special type of microscope used. Sharp focussing was accomplished by looking into a side tube containing a prism that could be pushed back of the objective lens to bring the light to the eye. Dark filters were necessary to protect the eye from the intense light used and he emphasized the necessity of an outside shutter to protect the subject from the light and heat at all times other than during the actual exposure. In addition the light was passed through a solution of alum and glycerine to take out much of the heat. The photochronographic film carrying mechanism (fig. 6) was attached to the right hand side of the microscope (fig. 8). The exposures were to be less than $\frac{1}{1000}$ second. Later the microscope was taken into the dark room and a screen placed on either side of the opening to the film carrying apparatus so that the operator could see when the subject swam outside of the field and stop the mechanism to save film.

Weiss (1896) seems to have been the first person to use an electric light concentrated on the object with a lens instead of sunlight. He photographed frog hyoglossal muscle under the microscope with a water immersion lens.

Marey's first motion picture projector was used in 1893. The film was moved with an intermittent movement. The illumination was supplied by the ever present heliostat but the appearance on the screen was jerky and unsatisfactory. The next year[3] Edison equalized the projection intervals of the pictures by perforating the film and guiding it

[3] From Marey (1901) and true because Edison's Kinetoscope only reached France in 1894 although the patent application for it was dated 1891 in the United States and the first public demonstration was given in the United States during 1893.

through the machine with sprockets bearing pins. The film passed continuously through the machine but as the illumination of the pictures was only $\frac{1}{7000}$ second the movement appeared to be continuous as the observer looked at the film through an eyepiece mounted on the side of the projector. The following year, 1895, Lumiere invented a claw movement to move the film intermittently and showed a satisfactory picture about 25 x 19 feet on the screen from a 25-x-22-mm. film image (35-mm. film). Marey devised a photochronographic projector in 1898 which gave equal intervals of projection but which did not require the perforation of the film. He preferred this type as he thought the wear would be undue on the perforated film as compared to distributing the wear over the entire surface of the film. Uneven wear or stretching would vitiate his precise analyses of the motion of the animals photographed.

The history of the methods given in the Smithsonian publications (1901) attributed the use of the photochronographic outfit with the microscope to the year 1899 but this must be an error as the method is clearly described in Marey's book *Le Mouvement* published in 1894.[4] By 1899 the photographic gun was modernized with an electric motor drive in the stock and the use of a film 66 feet long instead of the single revolving plate with room for only 12 exposures.

The first medical films were made of an operation by the French surgeon Dr. Doyen in Paris in 1898. They created a real scandal and much opposition. Doyen answered his questioners and critics that the films were solely for his own education and that of his students. Coissac (1925) truly writes that this marked the entrance of the cinema into education.[5] Their debut in the United States was at Boston by Dr. Walter Chase in 1906.

Hitherto the problem was to analyze motion taking place more rapidly than could be followed by the eye; our slow motion photography. The converse problem of stop motion photography seems first to have been used by Pizon in 1904. He coined the word *biotachygraphy* meaning

[4] It is not the purpose of this essay to establish to whom credit is due for the invention of the motion picture machine, but rather to point out its rôle in biological photography. Readers interested in the former question are referred to Lubschez (1920) and Coissac (1925) for the details of the conflicting claims and evidence.

[5] "*Le cinéma éducateur était né*, mais l'example devait attendre longtemps pout porter ses fruits jusqu'à lAcademie de médécine, òu la cinema contribue régulierement aujourdhui a l'enseignment de la biologie, de le médecine et de la chirurgie." P. 526, Coissac (1925), italics his.

to write life rapidly, to name his new method. It seems too bad that the use of this picturesque word has lapsed. Pizon studied the development of a colony of the tunicate *Botryllus* and his first film contained 775 images taken at a rate of three per hour on a 15-m. 50-cm. film. Thus he covered the decline of the first star-like group and the development of the second during a period of 10 days and 18 hours. The second film contained 250 images on a 6-m. strip. He showed these pictures at the 1904 Zoölogical Congress at Bern.

The use of these methods was continued by the students and associates of Marey after his death in 1904. His colleague and successor at the

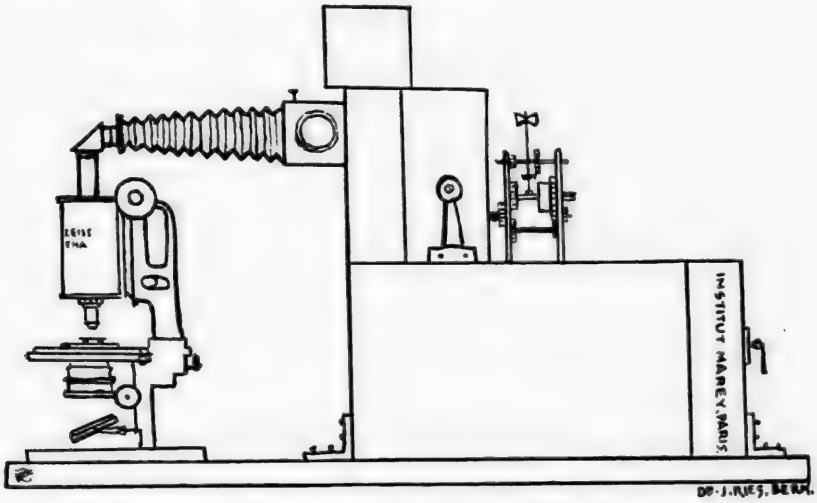

FIG. 9. ARRANGEMENT WITH MICROSCOPE VERTICAL USED BY RIES (1909)

College of France, François-Frank, reported a study of the passing of colored liquids through the respiratory tract of small aquatic animals in 1907. In some cases the path of the liquid could be followed but in other cases the animal refused to take the colored liquids used.

Carvallo summarized the main studies at the *Institute de Marey* at the International Physiological Congress of 1907 in Heidelberg. Athanasia and Bull were then making stereoscopic pictures of the wing movements of insects at a rate of 2000 pictures per second using an electric spark for a brief intense light source. X-ray pictures were being made of the working of the digestive tract at rates of from one per hour to ten per second. The pictures were timed by a chronometric switch in the primary circuit

of the induction coil which furnished the electricity to the x-ray tube. These pictures made on the intact living organism were compared with the pictures made on the exposed digestive system of animals other than man.

Ries (1909) studied the fertilization and division of the sea urchin egg during 1908, using a photochronographic outfit loaned to him from the Institute of Marey. He modified the arrangement by using his microscope in a vertical position with a prism to reflect the light at right angles from the microscope to the photochronographic outfit (fig. 9).

During this period the equipment was continually improved and the next summary of the improvements made in the laboratory of François-Frank, at the College of France, was published by Miss Chevroton in 1909. An arc lamp drawing from 20 to 50 amperes at 60 volts was then used. The segmental shutter in the light beam between the arc and the microscope was set in degrees; e.g., at 11° with 30 frames per second the exposures were only $\frac{1}{960}$ of a second. The microscope was used in a vertical position and the photochronographic apparatus was set on supports so that it could be raised and lowered above the microscope with a minimum distance of 24 cm. When still photomicrographs were to be taken, a prism reflected the light into a nearby horizontal camera, (fig. 10). The camera equipment was driven by an electric motor and was aligned with the aid of water levels and plumb bobs. The microscope was focussed by looking at the image on the film through a prism colored red for safety and in addition a grid could be projected onto the film when such a background would aid the later analysis of the pictures. A water cell was used to absorb the heat from the beam of light.

Chevroton and Vlés photographed the development of the sea urchin egg in 1909, taking 1 picture per second during cleavage and one every seven seconds during the later stages of development. The changes from fertilization to the pluteus stage were recorded in about 8000 frames. They noted the oscillatory movements of the protoplasm when the projector was run rapidly appearing to have a period of several minutes. They suggested that these might be timed and studied with a stroboscope. This suggestion is still valid as the "foaming or boiling" seen in films of cellular activities has not yet been adequately analyzed; it is usually just taken for granted. These investigators were not aware of Ries' previous film on the sea urchin when they made their films.

Henry photographed and studied Brownian movement, in the Labora-

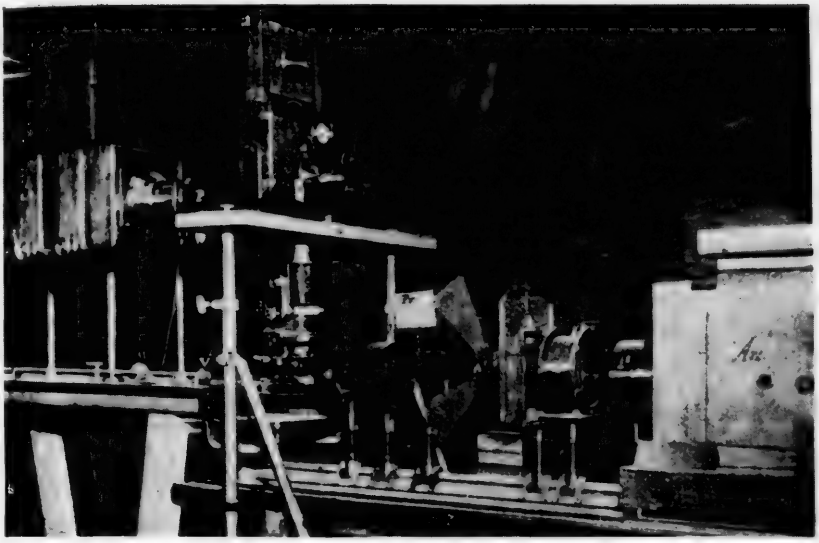

FIG. 10. ARRANGEMENT USED AT THE COLLEGE OF FRANCE DESCRIBED BY CHEVROTON (1909)

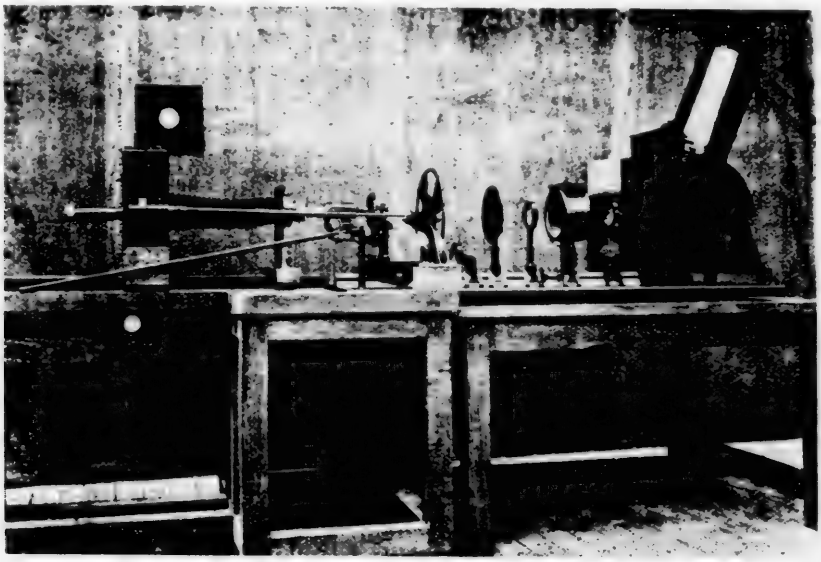

FIG. 11. COMANDON'S EQUIPMENT IN THE LABORATORY SUPPLIED BY PATHÉ From Coissac (1925)

tory of François-Frank. He interested his friend and student Jean Comandon in this work and Comandon's first results were presented to the French Academy in 1909. The facilities at the College of France soon proved inadequate so Comandon obtained the interest of Pathé in his project. Pathé furnished him with funds and equipment. He built his equipment with a massive optical bench and used the microscope in the horizontal position (fig. 11). The film was contained in a Pathé camera modified for this purpose. Light was furnished by a 30-amp. arc and a revolving shutter kept the light from the microscope except during exposure and the shutter was synchronized with the camera film movement. He studied bacteria with the ultramicroscope. Dark field illumination was obtained with a Sidentopf parabolic condenser. Sixteen pictures were made per second with exposures of $\frac{1}{32}$ second. The microscope carried a Zeiss 4-mm. objective and a No. 4 projection ocular. Most of the work was done with a magnification of 280 but the Brownian movement was taken at 600 diameters. As part of his work for Pathé Comandon later made films of amoeba, vorticella, trypanosomes, spirochaetes and of blood circulation for distribution as teaching films.

Thus we see that all of the basic features of cinephotomicrography were in use by 1909 with the exception of microscope incubators, powerful filament lamps and the synchronous motor drive.

The first cinephotomicrographic film of a growing bit of tissue cultured *in vitro* was made by Braus (1911) working in Sidentopf's laboratory at the Carl Zeiss Company in Jena. His pictures were taken at ten exposures per minute for ten hours and when they were projected showed the growth of a nerve, the growth changes of the pigment, and mesodermal cells. Unfortunately the apparatus used was not described.

The movements of the chromosomes during the development of the sea urchin were not clear in the films but were clearly shown in films made by Comandon and Joly (1913) of the dividing erythrocyte of *Triton*. Thus the film confirmed and objectified for those who saw it the previous cytological studies on this cell by Joly (1904).

A discussion of the changes in cell shape during the growth of tissue cultures was possible from study of the film made by Comandon, Levaditi and Mutermilch (1913). They used a Nernst lamp for illumination and took the pictures at 19 frames per second and projected them for study at the usual rate of 16 per second.

The changes in apparatus as they were developed from Marey's origi-

nal photochronograph were summarized by Comandon (1913). In addition to those cited here a study was made by him and Pinoy on the movements of myxomycetes. Comandon here emphasizes the extent that the cinema was developed by the biologists and regrets the fact that the resulting cinema industry was not contributing more to biology.

Later Comandon published two papers on phagocytosis (1917, 1920) wherein he made effective use of cinephotomicrography in the analysis of the activities of the leucocytes but these gave no further improvements in the photographic technique. The development of other apparatus, mostly modifications of the original outfits, made possible by improved materials, became general about this time. The use of the method spread to other countries and several of the more modern machines have been described by Heard (1932) whose paper should be consulted. He omitted the developments made in Germany and mention of the apparatus used by Krogh and Rehberg (1924) for the study of the blood capillaries. The latter simplified the focussing of the camera by having a mirror which reflected the image from the film to the eye through a side tube.[6]

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[6] Since this paper was written another description of the apparatus used at the *Institute de Marey* has been found in L. Bull's "La cinematographie." 1928. Paris. 180 pp. Appropriate gears on a shaft drive the camera and the rotating, sector shutter which latter is placed between the arc light and the microscope mirror. The microscope is used in a vertical position and a piece of plane surfaced glass is set between the ocular and the prism of the camera to reflect part of the light (about 10%) to a screen placed in the same focal plane as the film but below the film. This weak image is used as a visual guide in focussing the microscope.

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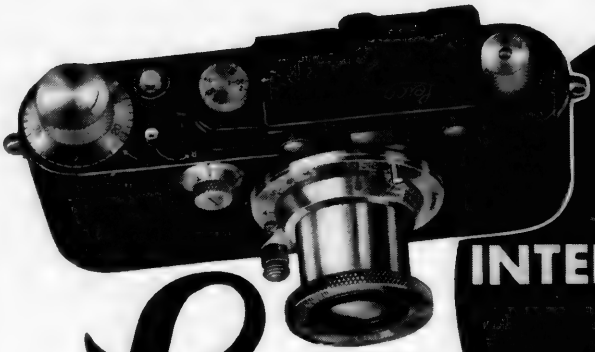

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EDITORIAL

THE PROPER LIGHTING OF PATHOLOGIC SPECIMENS*

There are decided advantages in having a definite set type of lighting for photographing pathologic specimens. This means the way the light falls upon the specimen and from what direction it comes. The definite type of lighting that is recommended is called *upper left hand corner lighting* and has been established as a standardized arrangement of lights, shades, and shadows by medical artists for some years. Possibly 95 percent of medical drawings are produced using this arrangement.

To simplify the meaning of this standardized type of lighting for pathologic specimens, the following requisite is given: the light source must be above and to the left of the specimen, thereby casting shadows to the right, within the specimen, and on the background. The advantages of this type of lighting are many.

A set and standardized type of lighting arrangement can establish its right and left side and the position of the specimen in the body, providing the specimen is placed in that position when photographed. For example, once this type of lighting is taken as a fact by physicians and other scientists, they can determine whether such a specimen as a kidney is a right or left kidney and whether it is front or back view. Every specimen should be placed on the background in exactly the position in which it rests in the body. When a posterior view is taken, it may be necessary to express this fact in the caption. Nevertheless, a simplified standardized lighting arrangement will simplify matters in interpreting the photograph.

* Received for publication September 1, 1933.

On the other hand, should any arrangement other than upper left hand corner lighting be used, as is generally done today, there is a certain tendency to puzzle over the position the specimen would take in the

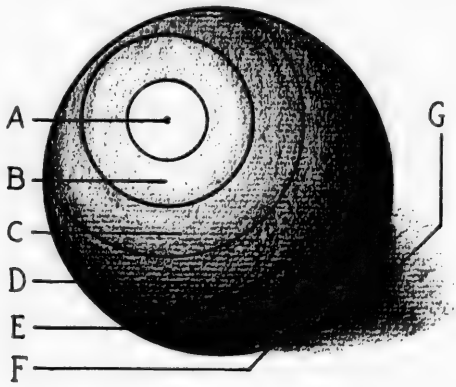

FIG. 1

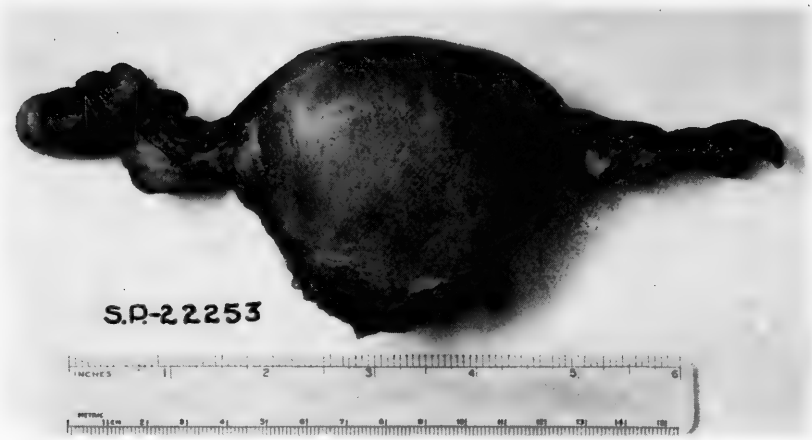

FIG. 2

living body. It is also difficult to determine its right or left side and top or bottom. Once this lighting becomes an established fact, scientists will look for it to help orient themselves to the photograph.

This type of lighting can still be used to help determine the body position of a sectioned specimen except in rare cases. For example, such a

lighting effect can be used in sagittal, frontal, and transverse sections. In rare cases it will not help to determine the body position; however, it will not hinder the interpretation of the specimen any more than any other type of lighting, but, in the long run, will simplify its meaning.

For further clarification of this type of lighting, let us analyze it. About the simplest example of the gradation of tone as created by upper left hand corner lighting is obtained by looking at a ball (fig. 1). Let us analyze this drawing. Since the light strikes the ball from the upper left hand corner, we might say that the area, *A*, is first to receive the light. Therefore, *A* is the lightest point. *B* becomes slightly darker, *C* becomes darker still, and so on through *D* until we find *E* the darkest part of the ball. In this way we have a gradual gradation of tone from the very center of *A*, which is the highlight on the ball, to its darkest tone, which is at *E*. We then often, but not always, run into the reflected lights. In this picture the reflected light is at *F*. This reflected light is cast from the base upon which the ball is resting. *G* is the shadow from the ball and we find that the reflected light, *F*, is impinging between the two darkest areas of the drawing which are *E* and *G*. Make the comparison between *F* and *A*. *F* is not as light as *A* which bears out the rule that a reflected light is never as bright as a highlight. In this case, and generally, the reflected light is of about the same tone as the area next to the darkest tone. This drawing simplifies the many tones into five major tones or areas, which seldom exist in the average subject.

Figure 2 is a photographic example of a uterus taken with upper left hand corner lighting. It is the anterior view which is further substant tiated by the tubes, ovarian ligaments, and part of the broad ligaments. Should this type of lighting and placement be an established fact, it would be more evidence toward showing its position in the body and its respective sides in true order.

While the shadow from the specimen to the background is not necessary, it becomes added evidence when included. Otherwise, the shadows within the specimen and its darkest or shaded side become all the information that is necessary.

CARL D. CLARKE.

SOUND MOTION PICTURES IN OBSTETRICS*

JOSEPH B. DeLEE, M.D.

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Only in obstetrics have I made motion pictures, but with a few modifications my remarks would apply to the whole field of clinical medicine. I have done but little with animated drawings and microscopic pictures, and this with the standard procedures known to all readers of this JOURNAL. My experience in taking operations is large and I have some notions of the value of motion pictures in obstetric teaching and practice. Perhaps the reader will be interested in these.

1. Equipment. I have no doubt but that the 35-mm. camera secures the best results, i.e., if one aims at producing something of real and permanent value for medicine. True, the optical instrument and camera makers very recently have supplied 16-mm. cameras and attachments that permit accurate delineation of the field, perfect focusing, fades, stop motion, slow motion, micro-photography, etc. Yet I feel that the results cannot compare with those of the larger film—if one aims at perfection. The cost, however, is almost prohibitive and one usually will have to be satisfied with less. What is said here of the silent, is true of the sound equipment also. If one wishes to publish and circulate 16-mm., both silent and sound film, a reduction from the 35-mm. will give better results. Improvement in 16-mm. apparatus is going along rapidly and in a short while, perhaps, we may be able to dispense with the 35-mm. except for large audiences. Since the instructional motion picture is shown less frequently than the latter, the narrower film will be the most generally adopted. The motion picture unfolds its greatest usefulness for instruction when shown by the teacher in small groups. Seated around a table before a screen, the lecture, quiz or conference becomes a living lesson. The picture can be shown repeatedly, reversed, doubtful subjects cleared up, and discussed again and again. The single showing in a large hall is more entertainment than instruction.

2. Film. Whether one has 16 or 35-mm. equipment it is best to use negative and positive stock. My experience with 16-mm. reversal film has not been favorable, especially for microscopic pictures; and copies from reversed film are not up to standard.

For ordinary obstetric operations where the field is large, and much light is needed, and heat is to be eliminated, the latest superpanchro-

* Received for publication August 25, 1933.

matic film is best. It is so fast that one can use a small lens aperture to get good definition. In surgical operations where the field is small and a cold light practicable, the ordinary panchromatic film is preferable because it is a little less grainy. I prefer Eastman film for general use, and Dupont for surgical operations. I have given up the use of filters, having found that under Mazda lights the tissues show the differentiation of colors better without them. Here lighting and lens aperture are all important. Certain tissues show best under ultraviolet light.

3. Taking pictures. If one desires really good pictures one must employ a trained surgical cinematographer. Most medical pictures are very amateurish—indeed they are not intended for more than local use—and for small groups or class work. With the latest model 16-mm. cameras made by Eastman and Bell and Howell one also needs an expert cameraman and further, the operator must not have to think about the technique of the photography. He must concentrate on his operation and what he wants to teach. For this purpose he must have prepared for every contingency in advance. As will be explained later, there are two kinds of medical motion pictures, the "basic subject" and the "case history,"—the latter is a cinematographic record of the case of a particular patient. The former is a rounded presentation of a subject in medicine or surgery, similar to a chapter in a medical treatise. The basic subject is a more ambitious effort and is a permanent addition to medicine, useful to universities and colleges all over the world, needing therefore every assistance from art, while the case report is of temporary interest and of restricted, usually local, importance. Occasionally a case history can be made into a basic subject.

The small film is also of use in medicine in teaching the technique of the laboratory, the sick room, or the operating room, to students, technicians and nurses.

As was said, preparations for filming a chapter in medicine must be completed before the first picture is shot. A scenario, a script, properties, titles, work sheets for the cameraman, the property man, the director, the script girl,—all these must be in readiness, and before the actual operation is begun, one or more rehearsals are necessary. These are for the silent picture, and if the film is to be a "talkie," the words to be used must be written in the script opposite the motions they accompany. Sound effects, if there are any other than the speaking, must be appropriately allocated. In short, one has to provide a bit of Hollywood in the operating room.

Our work is even more complicated because of the patient. In the first place we may not harm her. Without doubt the operation done for motion pictures could do harm. The intense light and heat to which she is exposed for perhaps an hour or more have, I find, sometimes raised her temperature a degree or two, quickened the pulse 20 to 40 beats, and I have even observed mild superficial burns. Probably there are also some chemical and hormonal changes in the system, produced by the light rays. Second, it is necessary to obtain a patient that presents the condition we desire to photograph (I am speaking now of the basic subject) and she must be a good photographic object from an esthetic point of view. A blond skin makes a better contrast than a dark one and blemishes would destroy the artistic effect and also, to an extent, scientific value. If awake, the patient must coöperate, and if asleep, the anesthetic must be a good one, and it may not be unduly prolonged while getting the picture—since anesthesia always has an element of danger. For this reason only a part of the total number of scenes may be taken on one patient. Often complications (not photographic) occur during the operation which ruin all the "takes" and this is particularly true of obstetrics—notoriously a practice of surprises. The assistants and nurses, too, create many complications—unless they are experienced in operating before the camera, and not seldom the cameraman himself will ruin an otherwise perfect performance. I had to do 15 caesarean sections to make one picture. Everyone, including myself made mistakes.

A well prepared script, to repeat, is essential, and certain parts of the picture are made each day, not necessarily consecutive scenes. Figure 1 is a page from the script I am using for a talkie of the Forceps Operation. Having decided to shoot part of the picture, the properties needful are assembled. We use a female pelvis and foetal head, clay models depicting certain hidden parts of the operation, sometimes drawings. The assistants, the operator, the cameraman, the script girl, all study the script and several conferences are held until everybody understands his part. Those scenes which can be rehearsed are done over several times until perfected. Naturally an operation can be done only once on on a patient, but I found it useful to practice the operation, as if for a motion picture "take" with the camera looking on, at other times, just to accustom every one to the technique. I have also used 16-mm. equipment to provide the experience for those who need it or are "camera

Sc. 24		Professor demonstrates on pelvis. Places foetal head in position, turns it to correspond with intended operation	CAMERA 3″ lens. ¾ view, semi close up.
Voice.	Prof.	*I place the head in the position it occupies in our patient and turn it in the direction nature would rotate it, if the labor progresses naturally.*	27 words, 30 feet.
Sc. 25		Full view of lecture platform and blackboard. A chart on wall. Set up No. 2.	
		Dr. Davis enters from left. Carries patient's chart and a stethoscope. (White suit, no mouth piece or cap.)	Cut. Now 35 mm. lens. Long shot at first.
Voice.	Dr. Davis	*Excuse me, Professor, our patient is having strong pains, every 2 minutes and the baby's heart tones, while not bad, are changing quality.*	23 words, 25 feet.
Sc. 26		Professor turns to class quickly. Speaks and then points hand to chart on the wall.	
Voice.	Prof.	*Gentlemen we must hurry to deliver this patient and while I am changing my clothes you might study the indications for the forceps operation.* (Points to chart and exits.)	24 words, 25 feet.
			CAMERA; pan to chart and dissolve into it. Foot No..... Reel No.....
Title 3		*THE INDICATIONS FOR FORCEPS*	
		Danger threatening { *Mother* / *Baby*	28 words, 30 feet.
		We deliver because the mother can not do it herself.	
		Either she is physically unable or she can not give birth quickly enough for her own or the baby's safety.	Dissolve to Foot No..... Reel No.....
Sc. 27		Amphitheater. Set up No. 3. Patient on table, draped, ready for examination. Professor at patient's side. Head piece and mouth cover. Is looking at patient and feels her pulse.	Long shot
Voice.	Prof.	*The woman is in good condition, heart strong, but she is not making progress commensurate with her pains. Remember there are 5 indications for forceps.* (Holds up hand and tells them off on fingers.)	25 words, 30 feet.
Sc. 28		Professor makes examination.	Dissolve to 2″ lens. ¾ view. Foot No..... Reel No.....
Sc. 29		Model showing what professor felt.	Dissolve to close-up of model.

A date stamped in this column indicates, this scene has been shot.

The numbers entered here guide the camera-man in his double exposures and lap dissolves.

FIG. 1. SAMPLE SHEET FROM SCRIPT OF FORCEPS TALKIE

shy," and to show them how their awkward motions appear on the screen.

Talking pictures. In all my pictures there are two kind of takes, a lecture or demonstration on models or on a patient, and the operation or delivery. For the former the operator does not have his mouth covered and therefore these scenes must be photographed and scored at the same time. This is done either in a studio or by means of portable equipment. When operating the actors' mouths are always covered, indeed most often in the picture faces are not seen at all and such scenes are taken as silent and later the voice is synchronized or "scored" in comfort at a studio. This is better and cheaper. It is not easy to operate on a patient under bright lights with two cameras going at a ruinous cost in film, and say exactly what you want to say. For the shooting of a silent take which is later to be scored, you simply operate as usual while the director reads the prepared script.

Photographing and scoring a lecture are relatively simple, it is filming the operation that requires the skill. If you will look at the sample sheet of script (fig. 1) you will notice that the time required to describe each step of the operation is carefully determined beforehand and the exact words to be used are written down. The Director (Dr. M. E. Davis has been helping me for years) reads these words while I am operating, and I adjust my time and motions to them. If I decide to change the wording to fit the particularities of the case I dictate to the Script Girl, and allow the cameraman to shoot an excess of the footage required.

A typical performance is as follows. Everything for the patient is done as usual; the cameraman has arranged his lights, and camera, and has "shot the slate"—this identifies the particular scene for the laboratory and for editing. The camera has an aperture plate which allows for a sound track. For sound on disc this is not needed. Shoot 24 frames per second. Director calls "Everybody ready! Lights. Camera." I start to operate. Director reads the appropriate words of the script and I act them. If the words mention a certain structure, I point to it; if a certain movement, I make it, giving each procedure the exact number of seconds required by the script,—often a few more, because for editing it is always best to have more footage than is necessary. One operates more slowly than usual and avoids all jerky motions. When this scene is taken the Director calls "Fade out. Lights." Cameraman is now told of the next scene and switches to a different lens

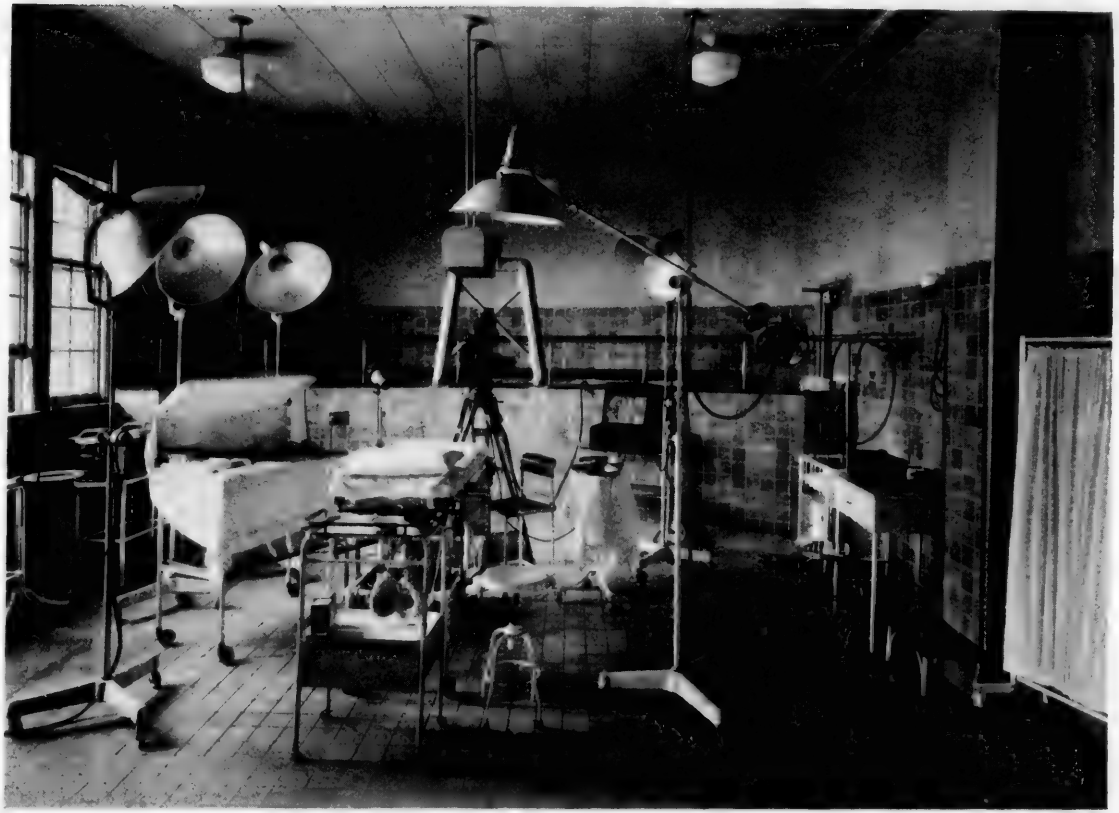

FIG. 2. BIRTH ROOM SET UP FOR DELIVERY AND MOTION PICTURE

Camera shooting delivery from below. Rear center, scaffold with tripod head to shoot from above, giving various camera angles. Operator, assistants and nurse wear gowns of light tan, not pure white which causes halation and flat pictures.

or to a different camera angle, or is asked to make a dissolve. Nowadays these effects can be done with the optical printer—but it is expensive.

When all the scenes have been taken the "editing" of the master positive begins, and this is easy or laborious, depending on the amount of forethought and preparation that have been made before the first picture was attempted, and the care used in rehearsals and filming. After the master positive has been completed, the scoring of those parts taken as silent is done. Perhaps a few practical hints on this part of the work may be useful for the beginner. It is not so easy to match words to motion,—it is easier the other way.

The film to be synchronized with voice is cut into lengths of not more than 200 feet and provided with a long leader. While the operator is comfortably seated at the microphone with the script before him, the scene is projected on the screen once or twice for rehearsal. When he knows just where the voice is to begin the film is punched with 2 sets of holes, one about 15 feet before the other. As the light flashes through the first holes, he calls out, "Get ready, camera." The sound camera is started and as the second flash shows on the screen, he shouts, "Go," and begins to read from the script. Instead of saying, "Go," one may clap the hands. This sharp sound marks the film for the sound editor. These speeches should be typewritten with large black type and wide spacing on 5 x 7 cards which should be dropped to the floor after reading, to obviate the crackling of paper when handled. The voice should be projected into the "mike" not directly, but a little from the side and below, to give a slightly muffled quality which will imitate a voice covered by an operating mask. It is necessary to watch the screen carefully as the picture unfolds to be better able to fit the words to the movements accurately, and here again a well prepared script, painstaking at the operation, and rehearsals, will achieve success. While it is expensive, one may have to make several "takes" of each section of film, and if the operator realizes that a certain take will be a failure he should clap his hands before the microphone and call out, "N. G." The sound engineer, who listens in all the time will call to the cameraman to stop shooting, thus saving film.

Sound effects such as the noise of a suction pump, the tinkle of a time bell, which we use to count the foetal heart, can be easily scored at the studio in the same manner as the voice. In obstetrics we need the cry-

ing of a newborn baby. Of course, the best way to get this would be to install a sound camera in the birth room and take the delivery part of the operation *ad naturam*, but I could not afford this. I took a newborn baby to the studio and placed it, while it cried, near the microphone. Then to get the gurgling first cry of the *neonatus* I dropped a teaspoonful of water into its mouth. The effect was perfect and the baby was none the worse for its experience, which is a very common one for babies during natural delivery. The sound effect is "dubbed in" by the studio sound editor, who matches the baby's voice to the motions of its mouth in the picture.

The difficulties, time, effort and expense, outside of apparatus and film, of getting high class pictures justify standard equipment and a professional photographer. A good negative of a great operation, or a famous operator is very valuable, and nowadays, with the optical printer, anything can be done with it—fades, dissolves, titles, compound pictures, double and triple exposures, duplicates, reductions, etc.

An entirely different matter is the "cinematographic case report." Whereas the "basic subject film" is prepared for world distribution and for teaching in universities, colleges and schools for nurses, the motion picture of a case is used by the surgeon who makes it, in his own hospital or school, for small classes, or for presentation to a medical society, sometimes only as a valuable part of his private case history. Here it is useful to show the progress of the patient's disease, the course of his recovery, and the nature of the treatment. Combined with still photographs, lantern slides, microscopic sections, x-ray plates and the written history it makes a mass of material unsurpassable in quality for diagnosing the condition, improving the doctor's technique, even helping to cure the patient. It might also be useful in a court of law. The neurologist, the gynecologist, and to a less extent the other specialists could use the silent and talking motion picture much more than they do, with benefit to their patients, themselves and their profession.

There can be no question regarding the general value of the motion picture in medicine. It is useful to teach students, doctors and nurses, and, with appropriate material, to educate the public in hygiene, etc. It also enables one clinic or professor to compare his methods with those of other clinics or specialists, at home and abroad, and to distribute knowledge gained in one school to others not so fortunately situated as to get it themselves, such as rare operations or laboratory tests.

Pictures cannot replace books, lectures and quizzes but they complement them and together make teaching trebly successful and permanent. Why, therefore, are the movies not making faster progress in medicine?

Answer: (1) The cost of producing good pictures, especially talkies, is almost prohibitive. Motion picture instruction should be endowed as are our private universities. Many public schools have incorporated the cinema as part of the curriculum, and the medical colleges should do likewise.

(2) There are not enough good pictures being made. Most have only local interest and value to the man who made them, or his hospital or school.

(3) Unfortunately, universities, colleges and heads of departments suffer from sectionalism (I don't like the word jealousy), also from too settled opinions. The professor therefore may not wish to teach what another man shows on the screen, perhaps holding it to be fallacious or bad practice. For me this is an advantage as it gives an opportunity to compare various methods. The teacher ought to be able to prove the better.

Many medical films are made by doctors for simple self advertising, which is frowned on by the code of ethics, but this evil will be cured in time. Business firms catering to the medical profession use the film to advertise their wares and it must be said that the majority of their pictures are excellent.

All in all I feel there is a brilliant future for the motion picture in medicine. By using different colored lights, and filters, the various newly invented emulsions, and probably the soon to be rendered practical color photography, all the fields of medicine will be conquerable for the ciné-camera, and our teaching will have dynamic living power.

MOTION PICTURES OF ELECTRO-SURGERY FOR THE RELIEF OF PROSTATIC OBSTRUCTION

HEINZ ROSENBERGER, F.R.M.S.

Sandy Hook, Connecticut and New York City

The value of motion pictures for demonstrating surgical technique has previously and repeatedly been emphasized in these columns. Today, motion pictures are projected everywhere at medical gatherings and give evidence of their usefulness and also of the variety of their application. Unfortunately, however, many of the films shown do not measure up to a certain standard of perfection, much to the discredit of the art. A good motion picture should give a complete account of the operating technique as employed by the surgeon in concentrated, but easily understandable, form. Careful planning before the camera work is undertaken is essential. Furthermore, intelligent editing, which includes the suppression of unnecessary scenes, after good photographic records are obtained, will help materially in producing motion pictures of professional quality.

It is obvious that the maker of surgical films encounters difficulties of many kinds, and especially so when it comes to photographing deep cavities. Oftentimes this seems even impossible, when the surgeon's instruments cannot be seen at all from the outside. Nevertheless in the motion picture art many problems can be solved.

The author should like to take this opportunity to describe here briefly some of his experiences in connection with his work on a motion picture for Dr. Clyde W. Collings, New York, on "Transurethral Electrosurgery for the Relief of Prostatic Obstruction."

The object was to give in motion pictures a complete description of an improved operating technique as developed by Dr. Collings. In such an operation, the whole operating field, as viewed through the eyepiece of a cysto-urethroscope, is approximately 10 to 15 mm. in diameter The incisions are done with loop and knife electrodes which are introduced into the tube of the instrument, the inside diameter of which is perhaps 7 mm. One of the two electrodes is used at a time together with a telescope with lamp attachment. It is obvious that actual cine-photographs of the operating field and the incisions with loop and knife, as seen by the surgeon through the urethroscope, could hardly be made, although they might not be impossible.

In the first place, the amount of light emitted by a small electric bulb perhaps 3 mm. in diameter is insufficient. Secondly, the tube of the urethroscope is too narrow for forming an image the size of a motion picture

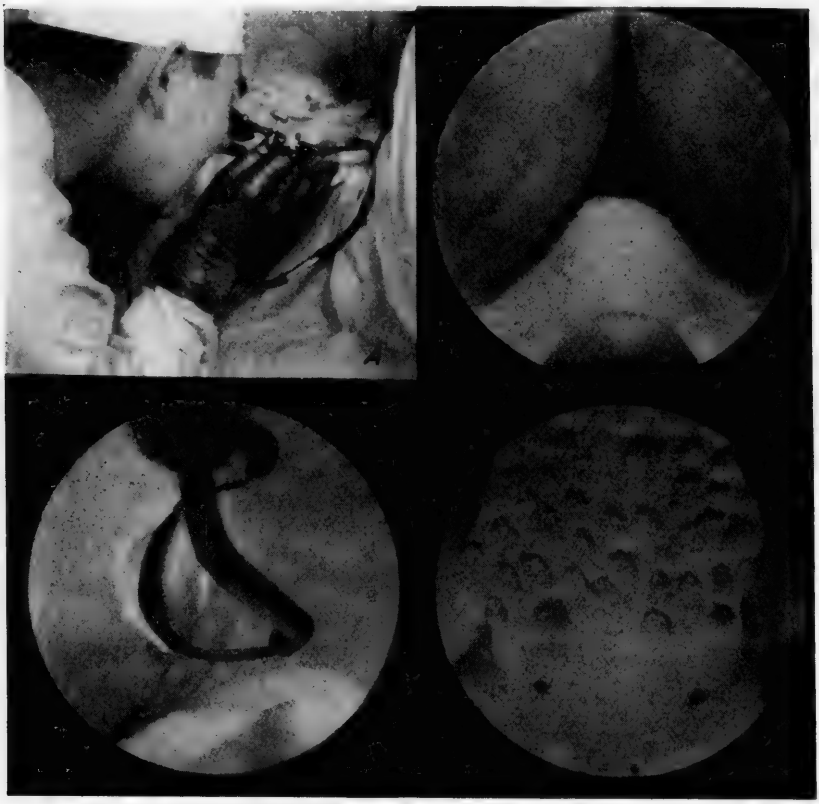

FIG. 1. PICTURES TAKEN FROM THE MOTION PICTURE FILM

A. The surgeon inspecting the field of operation.

B. Operating field with prostatic obstruction as seen through the surgeon's cystourethroscope before operation is started.

C. Loop electrode making first incision on left lateral lobe.

D. After operation is completed the interior of the bladder is visible in the background.

frame at a reasonable distance, and the speed of the objective would be much too slow for taking 16 images per second, as required. Thirdly, an instrument would have to be specially constructed with camera attachment, and beam splitting device, if the above mentioned difficulties of proper illumination could be overcome.

The author decided, therefore, to "perform the operation" on a plastilina model, as the main object was to give a clear description, rather than to make photographic experiments.

Before the work was started, careful studies were made at actual operations and on a corpse; pencil sketches made of the various phases. Thereafter, plans and time calculations were made for the animation work to be done on scale models of plastilina. Then a scale model of the interior of the bladder and the urethra 5 times original size was made

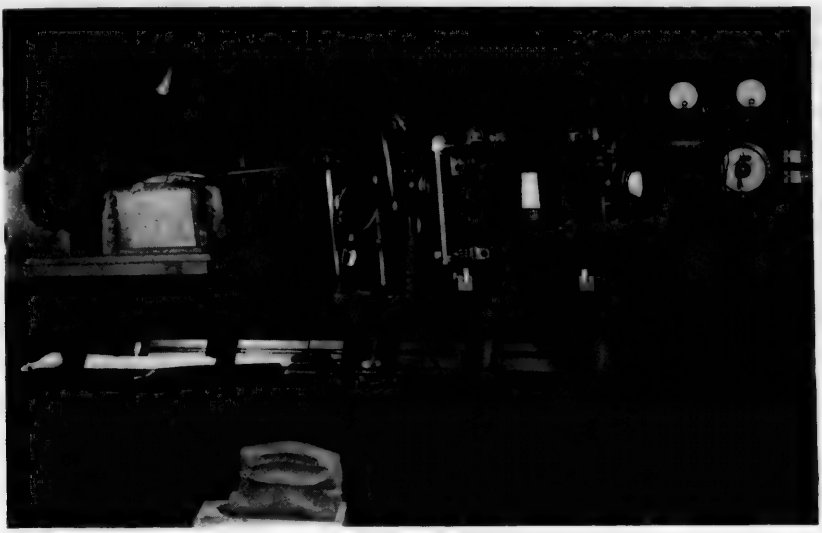

FIG. 2. OPTICAL BENCH WITH PLASTILINA MODEL; LAMPS AND MIRRORS, CAMERA AND TIME LAPSE (ANIMATION) APPARATUS

of plastilina around wooden supports which were to fit onto the riders of an optical bench. Of course, only those parts were modeled which could be seen through the camera. Those parts representing the prostatic obstruction to be "operated" upon were made in separate units, as they had to be moved separately forward and backward. Also the instruments, namely loop and knife electrodes, had to be made 5 times original size and supported and moved by means of special holders on the optical bench.

The camera was mounted on the opposite side of the bench also on movable riders. Lamps and mirrors were arranged in such a way as to give "natural" illumination in the narrow plastilina channel representing

the urethra. Finally the movements of each single unit were carefully marked on the optical bench and also checked on the ground glass of the camera.

For the single exposures of the animation work a time lapse unit with electric relay, exposure counter and motor, as used with the author's micro-cinematographic apparatus was employed and found to be of great value in saving time, and in securing even exposures. Exposures were made by pressing an electric button for taking single frames. This button is conveniently held in the hand.

After the animation work was finished the various phases of the operation were spliced together alternately with outside scenes of the actual operation from the plans previously worked out.

To many, who have seen this film projected, the illusion seemed to have been perfect, judging from the questions asked, as to how the operation was photographed through the narrow cystoscope.

PHOTOGRAPHING THE ORAL CAVITY

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From The State Institute For The Study Of Malignant Disease, Buffalo, New York

Photographing the oral cavity has always been a problem to the clinical photographer. Many types of infection and some pathology occur in this location, therefore it is desirable to produce good photographs of such subjects. Drawings are usually employed to illustrate diseases of the interior of the mouth, but often they are not as convincing as photographs. For more than six months we have been working on the problem of adequate illumination of the mouth for photography. Our method is very simple and if followed closely will produce satisfactory results.

Four things are necessary for success in photographing this cavity. The order of their importance is: first, a coöperative patient; second instruments for securing the greatest aperture; third, proper lighting and fourth, photographic material. The first necessity, coöperation of the patient, is partly obtained by using the proper instruments for holding the mouth open. We have used cheek retractors, mouth gags, tongue forceps and tongue depressors.

The third requirement, i.e., proper lighting, has always been a stumbling block in this work. In an effort toward improvement, we have designed a light which was made by Mr. Alfred Borshal, instrument maker at our institute. Flash bulbs are used in this lamp to illuminate the mouth for photography. However, it is necessary to use an auxiliary 100-watt bulb for focusing. In order to speed up the operation of replacing the focusing light with a flash bulb, a socket receptacle adapter is used. These receptacles have a standard size electric light base above,

FIG. 1

and two prongs below. The prongs make it unnecessary to unscrew the adapter which can be pulled out and replaced with a flash bulb mounted on the same type of receptacle. This procedure is rapid and minimizes the disarrangement of the patient.

When taking motion pictures of the oral cavity a 500–watt light is recommended. By using a light of this wattage with condensing lenses, the concentration of light produces a degree of heat sufficient to burn the patient. This may be eliminated by using a water jacket in front of the condensers to cool the beam.

Figure 1 shows a photograph of our lamp. The top door is open and

the focusing bulb is in place. This is the bulb that is removed after focusing is completed, when everything is ready for the exposure. This bulb is replaced with a flash bulb. The diaphragm is cut down to F:45 and the picture is taken.

Figure 2 is a mechanical drawing of this lamp. The upper left hand corner of the drawing shows a rod which is attached to the reflector and is used for focusing. When this has been accomplished the rod is made

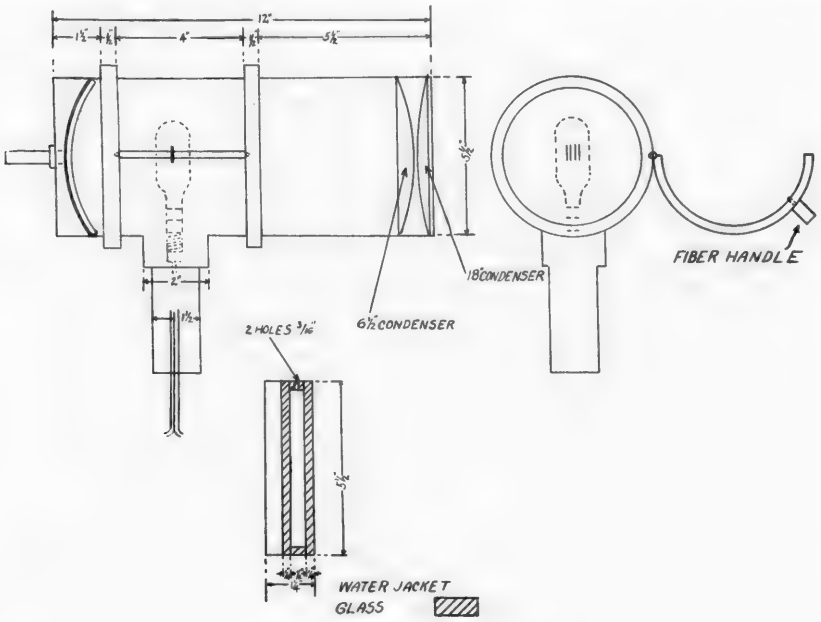


FIG. 2

stationary by tightening a set screw, after which it does not require readjustment. The two condensing lenses in front of the lamp are $6\frac{1}{2}$ and 18 inches in focal length. The reason for this is that the lens of short focal length is $6\frac{1}{2}$ inches from the flash bulb. At 18 inches from the surface of the front condenser, the light derived will give the proper coverage for photographing the oral cavity. The size of the illuminated area is the ratio of $6\frac{1}{2}$ to 18. In the upper right hand corner of figure 2 is a back view of the lamp showing it opened in order to change lights. In the lower part of figure 2 is a cross section of the water jacket which has

a capacity of about 75 cc. It will keep the beam of light cool for about twenty minutes, after which the water must be circulated. This can be

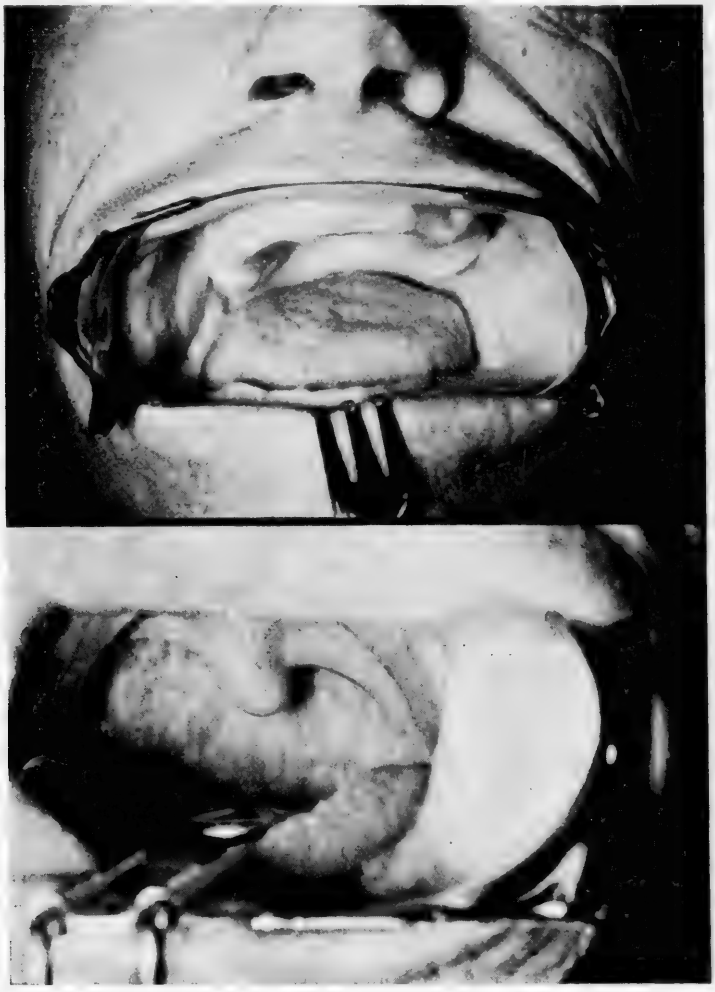


FIG. 3

accomplished by using the two small holes located at the top of the water jacket. These holes are $\frac{3}{16}$-inch in diameter. To each is attached a small rubber tube, one tube being used to fill the cell while the other takes care of the overflow.

Figure 3 shows the photographic result obtained with this lamp. The top picture is of the oral cavity with a mouth gag in place. The bottom picture in which a right angle tongue depressor was used is a closer view of the same patient. This gives a clear illustration of the uvula as well as the tonsillar area.

An Eastman clinical camera with an 8-inch lens was employed for this photograph. Eight lenses, ranging from 72 mm. to 48 inches, were experimented with in conjunction with this lamp. We believe that the result obtained with the 8-inch lens was best. When a lens of shorter focal length was used, it became difficult to obtain the desirable depth of focus; when a lens of longer focal length was employed, the object became more difficult to show, due to the small opening of the mouth.

The sensitive material was commercial panchromatic film exposed at F:45 with one flash bulb, developed in x-ray developer at 70°F. Supersensitive material may be used, but if the aperture of the diaphragm is F:45, overexposure is apt to result. This may be corrected by the use of a color filter, which will also give a better panchromatic rendition.

APPARATUS FOR MACROPHOTOGRAPHY*

CARL D. CLARKE

From the Department of Art, School of Medicine, University of Maryland, Baltimore, Md.

The various apparatus used for photographing pathologic or gross anatomical specimens are of many shapes and forms. The reason for this being that nearly every experimenter has designed his own equipment since there are none on the market that fully meet the diversified uses required of them by the average biological photographer. Few have taken the trouble to review the literature on the subject, having used their own ideas alone, with little outside help. It also stands to reason that the great difference of size and composition in the subjects to be photographed, has caused the photographer to devise equipment that is suitable only for his own purposes. On the other hand, some photographers are so highly specialized in particular fields and particular

* Received for publication August 1, 1933. Read at the September 1933 Convention of the Biological Photographic Association.

types of work that some of these apparatus vary in construction and size according to their needs. It is evident that the individual specializing in the photography of pathologic specimens for an institution devoted to the study and treatment of eye diseases is apt to design a smaller piece of equipment than the photographer employed by an institution undertaking the study and treatment of chest conditions.

The author believes that a comparatively universal equipment for the purposes described can be evolved from the many apparatus in use, meaning those that have been home constructed, and especially those that have been published in the current scientific literature.

This could be accomplished by designing a camera and stand of rigid construction, and adaptable for using many lenses of different focal lengths. In addition, it should have a subject support such as a table, that is also rigid and vibrationless. Such a support can contain a light box for making copies of negatives and lighting arrangements for producing copies of pictures, as well as the usual run of specimens of various sizes.

To reduce the effect of vibration it seems obvious that the camera support and object support should be separate. If they have a single base or support, springs should be incorporated in the apparatus for the purpose of absorbing vibrations.

Let us consider the fact that most workers desire an equipment that will not only make photographs of pathologic specimens but will also do copies, and the usual routine of biological work that is done in the average studio designed for that purpose. Of course, this is with the exclusion of clinical photography and photomicrography; however, the author can see possibilities of combining the apparatus for doing macrophotography and photomicrography in a single unit by the introduction of a microscope, proper lighting conditions, and a cooling and filter system mounted on an optical bench. This bench and equipment could be used as an auxiliary unit. Such an apparatus was designed by the author but was later abandoned to reconstruct a similar apparatus of better design, which at present has not been done. The main trouble with the old equipment was an excess of vibration when motion pictures of microscopic subjects were taken.

Where the photographer has plenty of assistance, and space for equipment, and sufficient funds available, such an apparatus loses some of its practical value. If there are more than one to use the equipment, it

becomes a hindrance rather than a help to have it combined all in a single unit as only one person may work with it at a time.

Essentially, such a unit for making photographs of pathologic specimens, copies of pictures, and reductions of radiographic or other negatives, is composed of the following parts:

1. A stand or tripod to hold the camera, preferably vertical
2. A camera
3. A light box
4. Sufficient lights

The stand or tripod is of many various constructions. Most photographers have built their own or had them built in local shops or by commercial firms. They are made from wood or metal or a combination of the two. Metal naturally is better material because of its rigidity. For this purpose a discarded x-ray tube stand or vertical chest plate holder serves admirably well. With a few changes, they may be adapted to hold the camera rigid and in a vertical position over the subject to be photographed.

The vertical position of the camera is by far the most desirable, as it becomes unnecessary to pin or tie the specimen to the background. It also eliminates the undesirableness of having to photograph the specimen from an angle when it is placed on a flat base, which will obtain a perspective of the background. The vertical placement of the camera makes it possible to photograph the specimen immersed in various solutions when desirable. Such a position of the camera permits an easy interchanging of opaque backgrounds or backgrounds formed by transmitted light.

One of the simplest tripods for this purpose is the one furnished with the Eastman clinical camera outfit (1) (fig. 1). This outfit embodies the simplest method of making photographs of pathologic specimens. By interchanging white, black, and various pieces of cardboard under or above the glass support, any desired tone of background may be obtained. A clear white background on the positive may be produced by photographing the specimen on a light box as seen in figure 5. The underneath lights are used for only part of the exposure. The two lights in figure 1 can be placed at different distances from the specimen to produce modeling, thereby accomplishing the desired pseudostereoscopic effect. It may be of importance at this point to mention the fact that when the specimen is placed directly on a piece of clear glass, care must

be taken to avoid reflections from the glass. Such an apparatus as figure 1 may be used for making copies, however, care must be taken in obtaining even lighting. Reductions of radiographic negatives may also be made with this apparatus, providing a light box or x-ray view box giving evenly transmitted light is used.

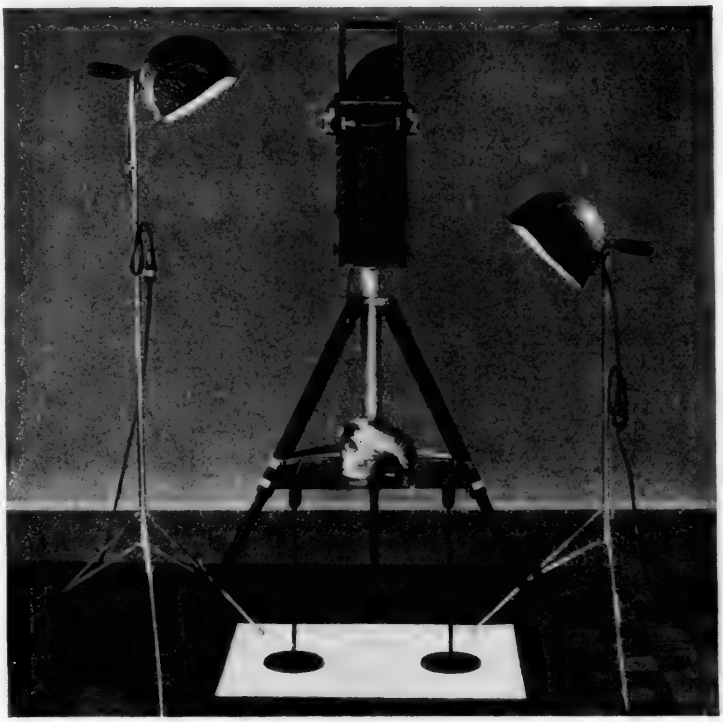


FIG. 1. THE EASTMAN CLINICAL CAMERA OUTFIT
(Cut by courtesy of Eastman Kodak Co.)

Such an apparatus as seen in figure 1 is possibly more adaptable for *clinical*, rather than *macro*photography. While it can be used for both, it stands to reason that as the desire for photographs of inert, comparatively small objects such as pathologic specimens, increases, it is obvious that an apparatus designed especially for this purpose becomes necessary.

In further consideration of the assembled equipment on the market suitable for making photographs of pathologic specimens, we have the Rexograph Auto-Focus Commercial Camera (fig. 2) and the Rexograph

Senior Camera, focusing model (fig. 3) which are manufactured by Burke and James, Inc., of Chicago. The smaller camera uses a 5″ x 7″ plate or film while the focusing model will take the 8″ x 10″ plate or film. The smaller camera is more suitable for small objects, while the larger camera can be used for objects of considerable size depending on the focal length of the lens and the placement of the stand. Should this

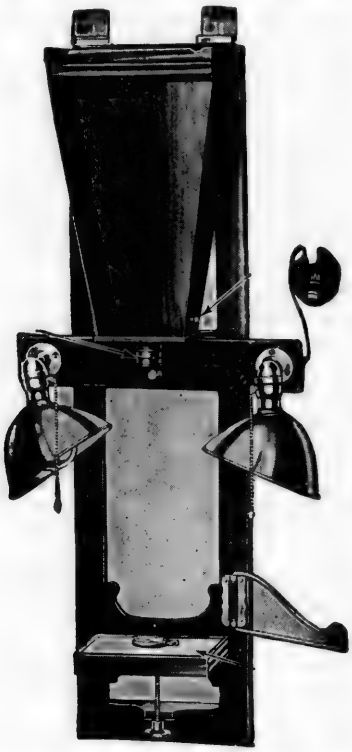
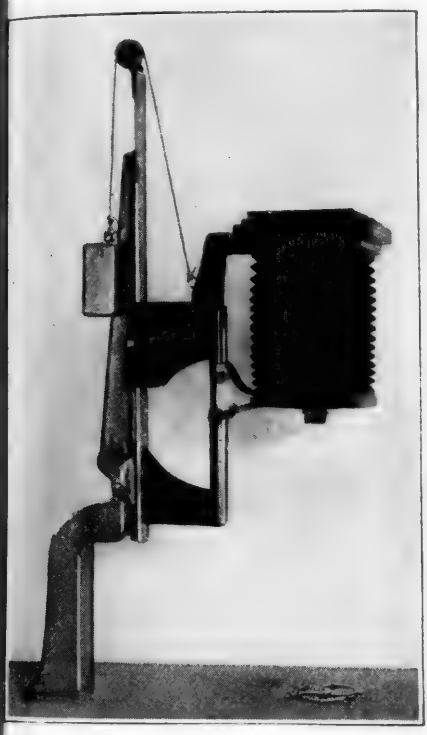


FIG. 2. THE REXOGRAPH AUTO-FOCUS COMMERCIAL CAMERA
(Cut by courtesy of Burke and James, Inc., Chicago, Ill.)

camera be operated from the top of a table, photographing the subject over the edge of and at a lower level than the table, it will naturally take in a larger field. The latter camera has a hinge in the stand that permits horizontal operation.

There are also cameras manufactured by Bausch and Lomb Optical Company, E. Leitz Company, and Zeiss Optical Company adaptable for macrophotography; however, most of these cameras are more suitable

for photomicrography and the photographing of very small objects. Changes are required to perfect them for the larger type of work. Due to the fact that a written request directed to these firms will result in



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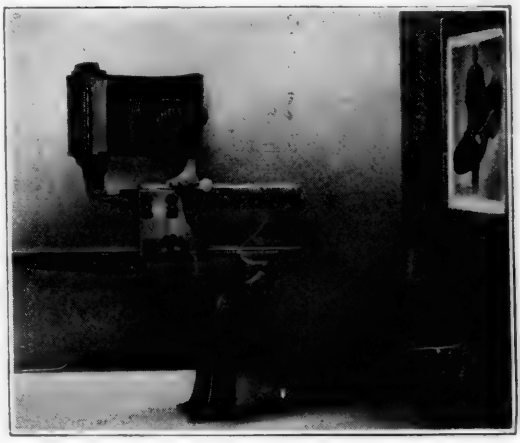

b

c

FIG. 3. THE REXOGRAPH SENIOR CAMERA

a. The camera in a vertical position. *b*. The camera in a horizontal position. *c*. An example of work done with this camera. (Cuts by courtesy of Burke and James, Inc., Chicago, Ill.

sufficient information as to their products, no more will be said of these cameras at this time.

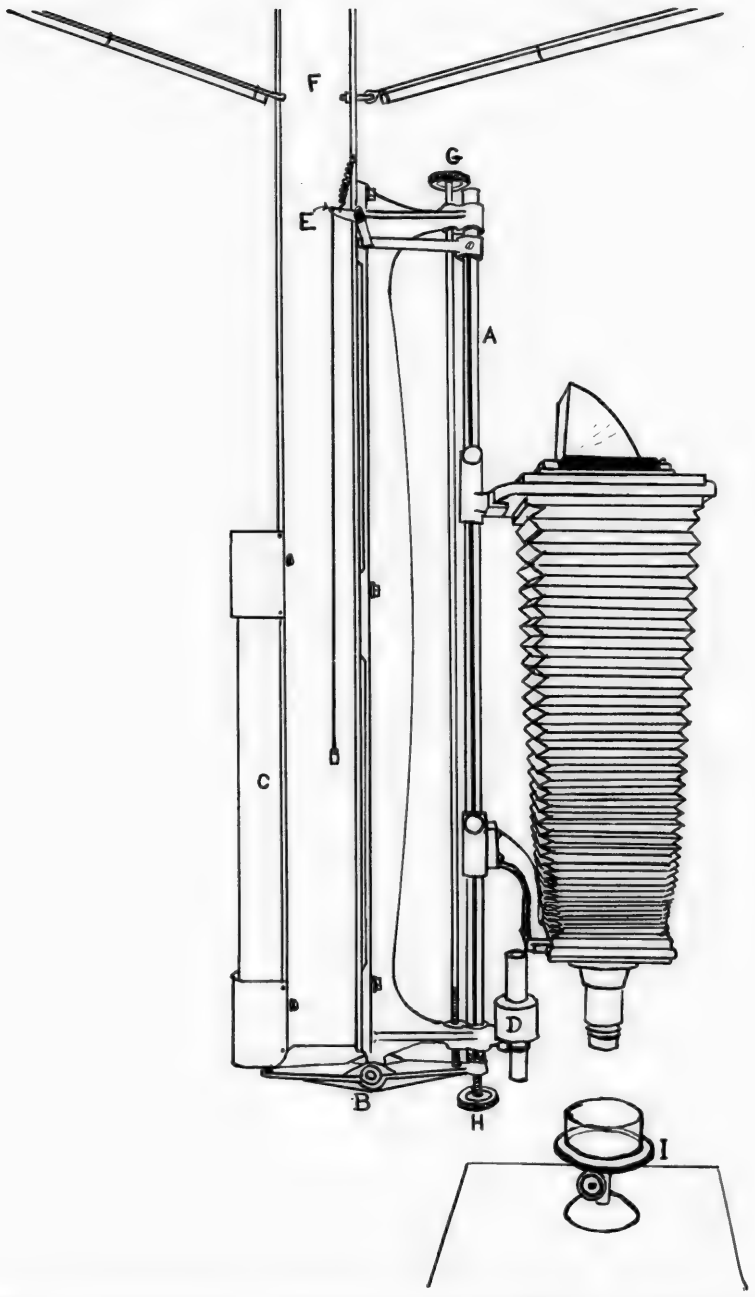

FIG. 4. *A*, optical bar; *B*, rocker arm; *C*, counter weight; *D*, monocular erecting body; *E*, camera latch with release cord; *F*, I-beam; *G* and *H*, focusing knobs; *I*, object stage.

In considering the specially designed camera and stand for macro and photomicrography, let us observe the apparatus developed in the Department of Embryology of the Carnegie Institution of Washington (fig. 4). Mr. Chester F. Reather, who operates this camera, gives the following description of it:

"In the Department of Embryology a need had been felt for a vertical camera that could be used for many purposes, such as photographing very small embryos, large drawings, and charts, and full term babies as well as similar material. The camera devised for these purposes has proven very successful.

"Instead of the usual laboratory stand, the camera is supported from the ceiling. Thus the camera is entirely separated from the photographic stage which is a great advantage in that it may be manipulated without jarring the specimen. Another advantage is the clear floor space for laying down charts or large specimens.

"The camera is an old Zeiss photomicrographic outfit mounted so that its optical bar may be rotated, whereby the camera can be swung out of the way while posing the specimen.

"To aid in centering and obtaining the correct position of very small objects, a Spencer monocular erecting body is attached to the base of the camera support. This low power microscope swings into the optical axis of the camera and is focused by the raising and lowering of the adjustable object stage, marked *I*, figure 4. The level in focus with the fixed microscope will also be in focus with the camera which is adjusted to the desired magnification by calibrations.

"The camera is counterbalanced with a 20-pound sash-weight by means of a rocker-arm across the base of the camera support. This gives a very easy movement to the focusing mechanism which moves the camera as a whole unit, keeping the magnification constant. To aid composition of the picture without rotating the specimen, a 4″ x 5″ Graflex revolving back has been mounted on top of the camera. This size is used for most subjects, but if desired the revolving back may be removed and the larger Zeiss plateholders with kits can be used. These accommodate 5″ x 7″, 6½″ x 8½″ or other desired sizes smaller than 6½″ x 8½″.

"The main support is a 2½″ x 4″ *I* beam, held rigidly and perpendicular to the ceiling by three ¼″ iron guy rods which are fastened to the walls near the ceiling.

"The table that is used under the camera for supporting the object stage and specimen has a removable blackboard top. This top can be replaced with one of glass for supporting specimens against a white background. The white background is used 4 inches below the glass to eliminate sharp shadows.

"A Bausch & Lomb convertible protar No. 10 VIIa, 7⅞″ focus is used for reductions and magnifications up to 3 diameters. A Zeiss 100 mm. planar gives magnifications from 3 to 8 diameters. Magnifications up to 20 diameters are obtained with a 48-mm. Micro-Tessar lens. For higher magnifications a wide tube microscope can be fitted to the camera with a light tight cone. Exposures are made by turning on and off the incandescent bulb illuminating lamps, eliminating the use of shutters."

A comparatively universal equipment for copy work, specimens, negative reductions, etc., was designed by the author in the Department of

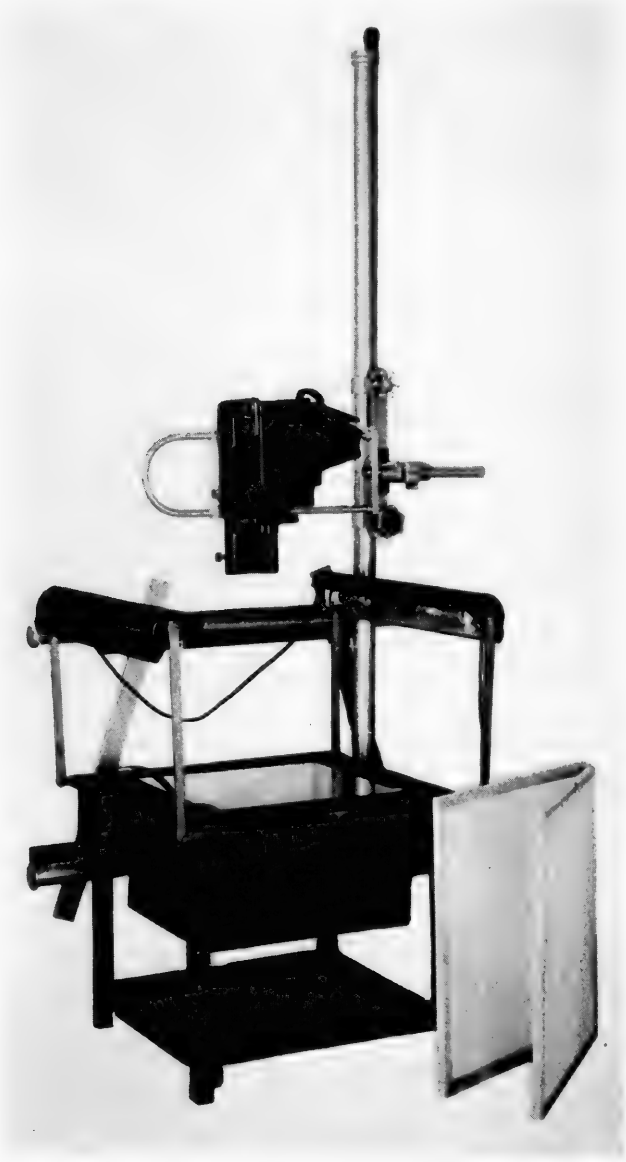

FIG. 5

Art at the University of Maryland School of Medicine. This outfit (fig. 5) is essentially composed of a camera stand and light box. The stand, which was made from a discarded x-ray tube support, moves right and left approximately 3 feet on ball bearing wheels supported by two pipes attached to the wall. The camera bed can be moved up and down approximately 4 feet, being counterbalanced by a weight within the upright support. It can also be tilted and moved about 1 foot right or left for fine adjustment after the stand has been locked in place by a set screw in back of the vertical support. The camera bed permits an interchanging of cameras of practically any size. In the illustration is shown a $3\frac{1}{4}''$ x $4\frac{1}{4}''$ scientific Graflex. This camera has plate holders adapted to take the $3\frac{1}{4}''$ x $4''$ lantern slide plates for making small copies, and positive lantern slide reductions of radiographic negatives. A $5''$ x $7''$ or $8''$ x $10''$ camera can be used on this bed for copying or making photographs of pathologic specimens.

The Graflex camera is used here as a matter of convenience of operation as the interposed camera mirror permits a right angle view of the ground glass as the operator works with his subject on the light box. This arrangement facilitates great speed in copying radiographic negatives or pictures from books for lantern slides. The operator may be seated on a chair or stool before the apparatus as he works.

In using a larger camera, a mirror mounted at an angle in a support and placed on the ground glass will prevent the operator from having to climb above the apparatus to get a clear view of the ground glass.

The light box table arrangement at the base is equipped with copying lights for uniform lighting. These light shields or reflectors were made from sections of roof gutters. The light box has four 100-watt bulbs in its bottom, over which is imposed a piece of ground glass and a piece of tracing cloth. The glass top to this box permits the copying of $14''$ x $17''$ or smaller radiographic negatives. A mat is used with any negative under $14''$ x $17''$. The top of the table permits the copying of $25''$ x $22''$ pictures or smaller. No other dimensions are given on this apparatus as each worker may desire to construct his own equipment of a size to suit himself. Switches for controlling the copying lights and the lights within the box are mounted on the right hand side of the table-like base.

The tracing cloth screen on the floor at the right hand side is used for diffusing the light from a single hand light in lighting fresh pathologic specimens. Such specimens are lighted on three sides by moving the

hand light around the screen, as shown in figure 6. When necessary, the shadow side of the specimen may be lighted with reflected light from a

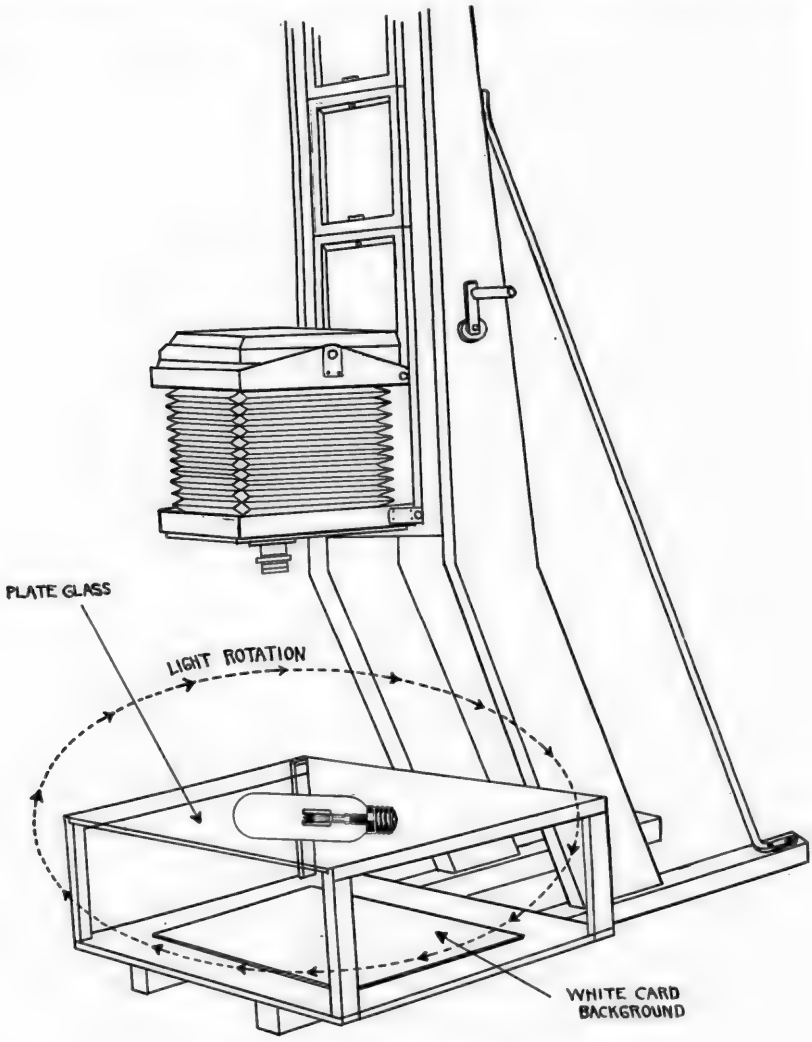

FIG. 6. MR. G. I. HIGHTOWER'S APPARATUS
(Cut by courtesy of "The Camera")

piece of white cardboard placed near that side of the subject but out of the field of the camera.

Figure 6 is an illustration taken from an article by G. I. Hightower (2)

in the August 1933 issue of *The Camera*. This gives an idea of such an apparatus designed especially for this type of work. From its general construction, evident by the possibility of a long bellows extension, the author believes it was designed more for obtaining magnifications of small objects rather than reduction negatives from larger specimens. However, it is also possible for this apparatus to be used on larger subjects. The ellipse shown by the dotted lines interposed with arrows indicate the direction taken by a single hand light for lighting the specimen. The author believes that this type of lighting is best for use on wet pathologic specimens, and small objects, for producing modeling, and a graduation in the highlights and shadows.

Louis Schmidt and Joseph B. Haulsenbeck (3) have developed a similar apparatus which was described in the December 1932 issue of this JOURNAL. In this article these authors show the use of the tracing cloth screen which greatly reduces the glistening highlights on wet pathologic specimens, thereby making it unnecessary to submerge them in liquids.

William F. Payne (4) also describes his method of taking this type of photograph in the March 1933 issue of this JOURNAL.

Joseph B. Homan (5), in the June 1933 issue of this JOURNAL, has developed a comparatively complicated apparatus for the same purpose. By a system of levers and cranks he claims to have simplified the focusing and centering of the subject. His apparatus also permits a great variation of work and is well worth considering for its convenience of operation and range of adaptability.

Dr. H. F. Pierce, of the Wilmer Institute of Johns Hopkins University and Hospital, adds the possibility of making stereoscopic pictures to such apparatus as is being described. His outfit is shown in figure 7. He gives the following description of it:

"This copying-camera stand was made from the tube-carrier and vertical standard of a discarded x-ray table. The tube-carrier was already counterbalanced by a weight running inside the standard and a chain passing over a sprocket at the top, and was provided with a lock for clamping the carrier rigidly to the standard. This equipment was modified by supplying the vertical standard with a rack and the carrier with a pinion, shaft, and crank. To the face of the carrier four $\frac{3}{4}$-inch steel rods were welded, and to the outer ends of these was screwed a slotted steel plate with a narrow ledge at the bottom to carry the camera. A tripod screw passing through the vertical slot in the plate permits the mounting of cameras of various sizes. The pinion crank is furnished with an automatic brake, which requires that the crank handle be pushed in, in order to rack the camera up or down. This brake is not strictly necessary, but would prevent the camera from falling if the counter-balance chain were to part.

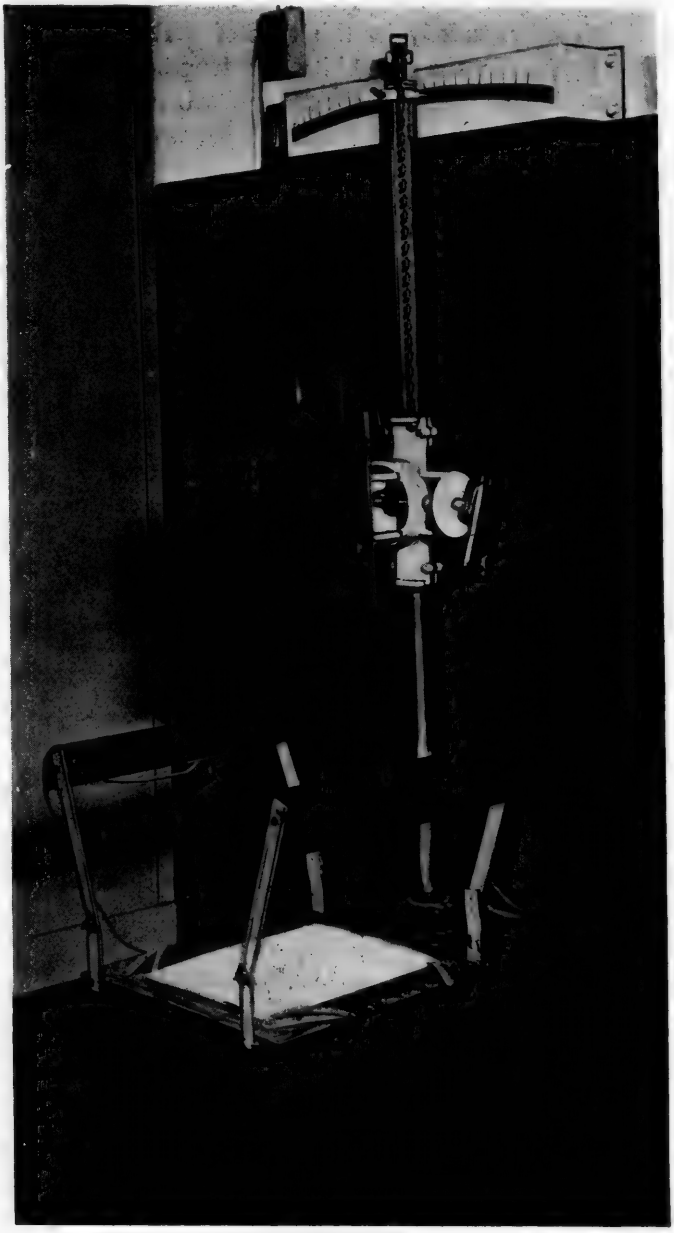

FIG. 7

"The vertical standard fits into a socket at the bottom, to which is attached, at right angles, a short length of 1-inch steel shaft. The shaft turns freely in a shafting hanger, which is bolted to the concrete floor of the laboratory. The top of the vertical standard is fitted with a clamp which allows it to be fixed rigidly to a face-plate which is bolted to the wall. The face-plate is laid off in degrees, and the standard may be swung 10 degrees from the vertical in either direction and clamped rigidly in any position. This permits the making of stereophotographs of pathologic or other specimens.

"The machine-work and mounting of this apparatus were very carefully done, so that the shaft is at right-angles to the standard, and the standard is at right-angles to the floor, and the camera mounting-plate is parallel to the standard and to the wall. The vertical travel of the camera is 45 inches. The horizontal axis of the shaft-hanger is 10-inches from the floor. The swing of the vertical standard is 10 degrees in each direction.

"The usual lighting equipment is a 'Copylite' fitted with four 75-watt lamps and paper diffusing screens, mounted on a low stool, though other forms of lighting are used on occasion.

"The lens equipment consists of a convertible 'Protar' set, having focal lengths of approximately 5, 7, and 12-inches, and a 'Dagor' lens having a focal length of 5 inches."

In Volume XX, Nos. 109 and 117, of *Contributions to Embryology*, Drs. C. H. Heuser and G. L. Streeter (6) describe their apparatus for making photographs of the early stages in the development of pig embryos, from the period of initial cleavage to the time of the appearance of limb-buds. Their equipment indeed marks an advanced step in the photography of small objects. Notably, they have not only designed a precision piece of apparatus, but have added a binocular microscope that operates in the same focal plane as the lenses which are probably of the Micro-Tessar series.

The following description is quoted from pages 7 and 8 of the article mentioned above with changes of figure numbers only to fit this text.

"In studying this embryological material, special efforts were made to secure adequate photographic records, both of the early eggs and of the embryo itself. For the larger specimens a shallow Stender dish with a glass cover was utilized, as shown in text-figure 8. The dish is completely filled with distilled water or alcohol and the cover slid on in a way to let the last air bubble escape. In the bottom of the dish there is placed a glass disk covered with a black vaseline which serves as a contrasting background and also makes it possible to accurately hold the embryo in position. This posing of the specimens is done by raising up or adding small bits of vaseline with needles to form appropriate supports for it. The dish should also contain a curved white cardboard reflector, which is placed just outside the field covered by the lens, for illuminating details in the shadows.

"When the specimen is installed in this manner a conical beam of light is thrown

obliquely through the cover of the dish so as to illuminate the surface of the embryo, bringing out in relief its delicate surface modeling. The principal object of the cover to this dish is to prevent any movement of the contained fluid. A special photographic equipment has been gradually assembled in this laboratory, which greatly facilitates the proper placing and illumination of these specimens. This equipment is illustrated in text-figure 9. It possesses certain desirable features. A binocular microscope and the camera are mounted on hinged supports so that when they are moved alternately into position their optical axes will be identical. Hence after the specimen has been adjusted under the microscope its image will fall centrally on the photographic plate. The board carrying the camera is hinged to another, supported at the top by a clip which rides over the arc and secured at the lower end by a bolt which serves as a pivot on which it can be tilted to the right and left for stereophotography. The arc through

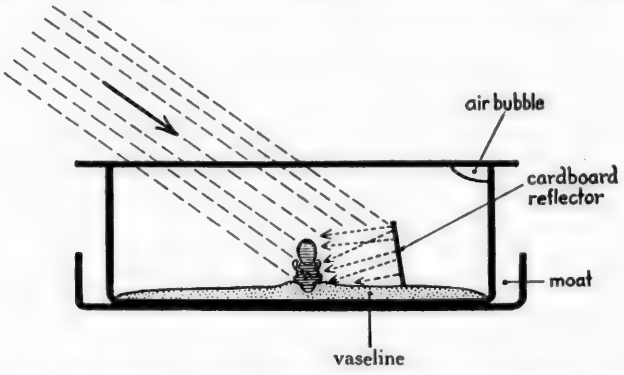

FIG. 8. GLASS CHAMBER IN WHICH EMBRYOS ARE PHOTOGRAPHED UNDER FLUID
It is usually best to illuminate the specimen obliquely from above with a beam of parallel rays, with some of them reflected to the shadow side. (Reproduced by permission of Dr. G. I. Streeter.)

which the top of the board moves is calibrated with equidistant holes on either side of the upright position, and pegs are inserted at the desired angles for the two images. The specimen is always placed at the level of the pivotal bolt so that the two images will in each case fall centrally on the plate. The placing of the specimen at this correct level is facilitated by mounting the microscope with its focus fixed on the level of the pivot, so that when the specimen is observed under the microscope and brought up to its focus, by means of a stand provided with a rack and pinion, it will be in the proper horizontal plane. The viewing microscope is then swung to the side and the camera moved into position above the specimen. The various objectives and the level of the plate holder are graduated in such a manner that any desired magnification can be secured by adjustment of the length of the bellows and level of the camera as a whole to a series of marks engraved on the side of the apparatus. The illuminating device consists of a 6-volt, 108-watt, gas filled Mazda lamp, provided with a Bausch & Lomb aspheric condenser. By focusing the condenser a beam of light of almost any desired intensity can be obtained. One portion of the specimen is brilliantly illuminated by

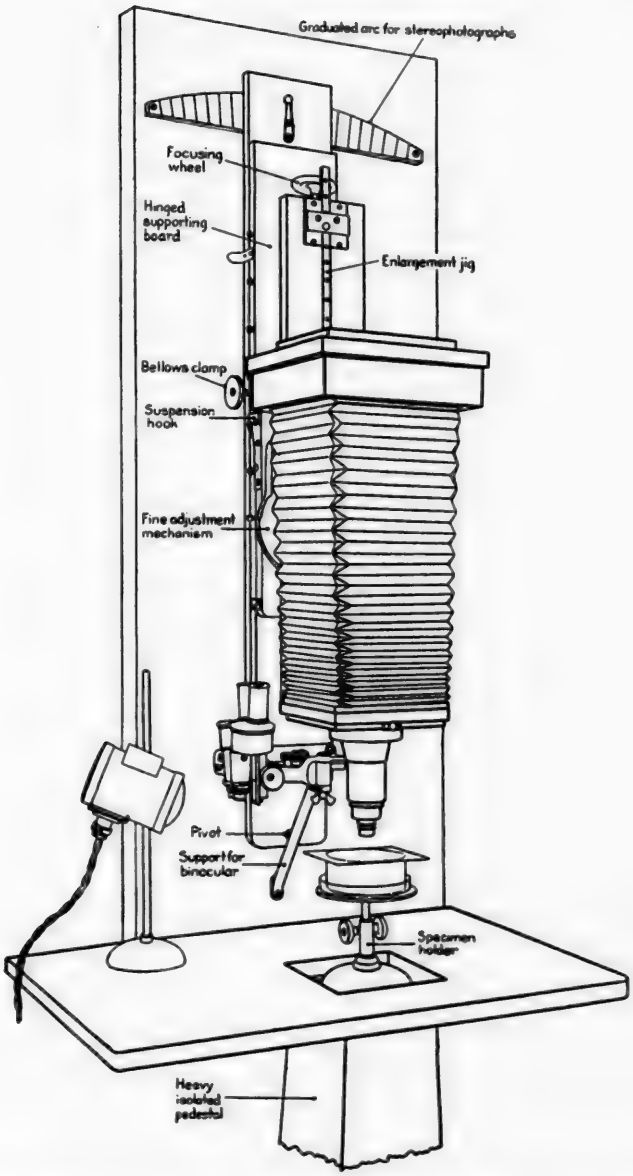

FIG. 9. DRAWING OF APPARATUS USED FOR PHOTOGRAPHING SMALL EMBRYOS
About $1\frac{1}{8}$ actual size
(Reproduced by permission of Dr. G. I. Streeter)

the lamp and the opposite surface is adequately shown by the reflex light cast by the cardboard reflector in the fluid chamber. The lamp rests on a shelf which is independent of the pedestal which holds the focusing stand, so that movements of objects on the shelf do not set up tremors in the dish containing the specimen. In order to obtain a firm pedestal, a wooden case was made in the form shown in text-figure 9, and filled with sand.

"For securing records of small eggs, the focusing stand is replaced by the ordinary compound microscope, so that the specimen may be illuminated with transmitted light. The eggs are placed on a 1 x 3 microscopic slide (in some cases a hollow-ground slide was used) rimmed with vaseline and covered with a cover glass. It was found that a hair could be left projecting through the vaseline ring, and by means of it the eggs could be adjusted as to position without disturbing the cover."

In further consideration of various light boxes for the photographing of pathologic specimens, Mr. Pedro Bunoan (7), of the Laboratories of Mt. Sinai Hospital, developed a lighting system that is different from those which are generally used. His apparatus consists of a box on which are mounted eighteen 40-watt bulbs, sufficient switches for their control, and a ground glass background for obtaining clear white backgrounds on the positive. His article appears in the December 1932 issue of this JOURNAL and is well worth considering.

As for the lenses and lighting effects used for taking photographs of pathologic specimens, there are as many variations in this part of the necessary equipment as there are cameras and camera stands. As stated before, due to the fact that the objects to be photographed in this work are inert or dead, a fast lens is unnecessary. The fast lens is apt to lack depth of focus and sharpness of field which are so very necessary in biologic photography. A lens possessing sufficient depth of focus, and focal length to compensate for the size of the plate used and give freedom from distortion, cannot be too strongly advised. Depth of focus and sharpness are necessary even at the sacrifice of speed.

The author believes that the average pathological specimen that is not to be greatly magnified in the camera should be taken with the light supplied by a single hand light revolved in an elliptic circle. If necessary, a white cardboard can be used to give reflected light. When the specimen is fresh or covered with highlights, an interposing screen as seen in figure 5 should be used.

Of course, some operators prefer to immerse the specimen in a fluid while making the picture. The author believes this method is best for very small specimens to be magnified in the camera and especially for

stereoscopic views. Figure 7 gives a good example of this type of lighting.

In conclusion, it may be said that the object of this paper is not to present anything definitely new, but rather, a résumé of apparatus that are in use at the present time. It is hoped that from these pieces of equipment workers in the field of biological photography may design with less effort the proper equipment to meet their demands. It is further hoped that their efforts will lead toward some orderly standardization of equipment and procedure.

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THE PHOTOGRAPHIC DEPARTMENT OF THE NON-TEACHING GENERAL HOSPITAL

ORGANIZATION AND CHARACTER OF WORK*

HELEN HANSON

From the Department of Photography, St. Francis Hospital, Wichita, Kansas

In a society in which most members are employed by large medical schools or research institutions it may seem unnecessary to point out the value of medical photography. From visits in eastern institutions I have gained the impression that its importance is generally recognized, not only by clinicians and research workers, but also by the hospital authorities. In the western states this is not always the case. For instance, in a medical school of a large southwestern state the first department which was affected by the economic depression was that of

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medical photography. It was entirely stricken from the list by decree of the governor. In a well known southern university I found the medical photographic department confined to a dingy room. The work was done quite efficiently, however, by a medical student who was working his way through school.

I will not talk about the quarters a photographic department has, or should have, in the larger teaching institutions, but I would like to tell about my experience as photographer in a non-teaching general hospital. Since most of the medical and surgical work in this country is done in such a general hospital as ours, I hope this may not only interest you, but perhaps be of benefit to biological photographers who are not fortunate enough to find a position in a medical school or research institution. I know that our photographic department is still far from the ideal. An ideal photographic department of a general hospital should be, first of all, independent of other departments. It should be financed entirely by the institution and should not be the property of one or several doctors. Furthermore, it should have a full time medical photographer. If you visit general hospitals of medium size you will seldom find one or several rooms with the necessary photographic equipment set apart as an independent unit. Very likely if the hospital photographic work is done at all you will discover a more or less antiquated camera in a corner of either the laboratory or of the x-ray department. The pictures will be taken at best by either the laboratory or x-ray technician, or perhaps by some doctor who has found a special hobby in medical photography during his spare time. You cannot expect efficient work under these conditions.

At St. Francis Hospital the necessity of photographic recording was felt first in the department of pathology. A photographic department was organized by the pathologist, Dr. C. A. Hellwig, as a branch of the pathological laboratory. A special room near the laboratory was equipped with a horizontal microphotographic camera, an 8″ x 10″ camera with an anastigmat objective for gross pathological specimens, and a small built-in dark room. It did not take long for the clinicians to realize the advantage of using this equipment for their clinical cases. To meet these demands a second room was set aside for clinical photography, and a clinical camera was acquired, together with the accessories for permitting clinical photographs with flash and floodlight. Our present photographic department, which in our opinion meets all requirements

for routine work in a non-teaching hospital, is prepared to do clinical photography, photography of gross pathological specimens, photomicrography, copies of charts, drawings, x-ray prints, black-and-white lantern slides, and color photography. It does not seem necessary before a group of experts to go into technical details. Only so much may be said, that we do all our photography and processing in artificial light; that we immerse our pathological specimens in a large water tank, and use for most specimens a fawn-colored background; that we prefer Wratten "M" plates 5″ x 7″ for all work, and print on glossy Azo grade A paper, and that we have accepted for color photography (lantern slide size) the Agfa Process. Our filing system is simple, but complete. The orders, which are accepted only from physicians, are entered in a journal. Each picture receives a number which is marked on the negative with a diamond point pencil. The plates are kept according to their number (ten in each plate box), in a special file cabinet. The print has the corresponding number of the plate stamped on the back. One print is filed in the photographic department, two other prints are attached to the patient's chart. We have a cross-index file in which the pictures are listed in groups according to the different organs. For the staff a lantern slide library is available with black-and-white and color photographs. This proves valuable for lectures or staff meetings.

Most of our work concerns gross and microphotography of pathological specimens. The next largest number of photographs are clinical photographs, especially those of orthopedic cases (fig. 1).

The state law for crippled children has been effective in Kansas for one year, and it is required thereby to have photographic records of the conditions of all state patients before and after treatment. A cancer clinic is being organized in our hospital at the present time, and we expect a large increase in clinical photography. Especially in skin cases, photography of the cancerous lesion before and after treatment, and also in the different stages of treatment, seems imperative. A somewhat more difficult problem than the photography of hospital cases is represented by requests of physicians not connected with the hospital. Illustrations for scientific papers, records of office cases and prints or lantern slides of x-ray films are frequently demanded by physicians of the city and surrounding territory.

How should the financial question be satisfactorily solved in this case? In our opinion the physician who orders photographic work for his own

use must be made responsible for the cost of the material and for the extra hours of work required of the photographer. We have found that a 5″ x 7″ photograph or photomicrograph cannot be made without loss to the institution for less than one dollar. In general, we have had the experience that the physician is willing to pay this small sum for a photographic record which may be of great value to himself and to the medical public. The expense for the photographic records of hospital

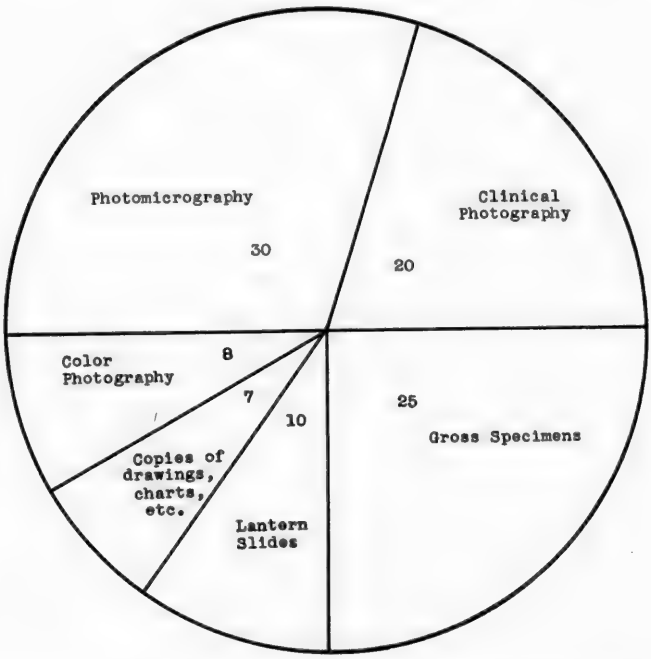

FIG. 1. PERCENTAGES OF THE DIFFERENT TYPES OF PHOTOGRAPHIC WORK OVER A TWO-YEAR PERIOD AT ST. FRANCIS HOSPITAL

cases and laboratory specimens of course should be met by the hospital. For their photographs pay patients could well be charged on the hospital bill an amount sufficient to maintain a fund which would allow for photographs in charity cases, postmortem specimens and connected matters, with slight burden to the private patients, but with far reaching benefits to those so aided. The hospital should realize that photographic recording helps to improve the scientific spirit and the reputation of the insti-

tution, and should be glad to provide funds necessary to keep the photographic equipment in perfect working condition, pay for the photographic material, and last but not least, offer a salary which is attractive to an able photographer.

It is our firm belief that the time will come when no general hospital will be regarded as complete without the aid of an efficient photographic department.

PHOTOGRAPHIC TECHNIC, NEW PROCESSES AND EQUIPMENT

F. R. HARDING

From the Photographic Department, Children's Hospital, Boston, Massachusetts

LATERAL ILLUMINATION OF CLINICAL SUBJECTS

Photographing patients with small cysts, raised skin rashes, etc. is difficult unless lateral lighting is employed. This consists of projecting a beam of light parallel to the object being photographed, with the camera at right angles to the object or patient. The photographs marked figure 1 shows a cyst of the left knee, made with lateral and flat lighting.

The patient is placed in a sitting position with the legs extended. The lateral lighting is done by placing a 1000 watt lamp and reflector slightly at the left of the patient's hips, pointing towards the feet. The lamp is then moved laterally until a maximum shadow is cast by the cyst. The flat lighted photograph was made in the usual manner. Lateral lighting is employed to show the distribution of fatty tissue in some types of glandular disorders, in posterior views of scoliosis, for cysts, for skin rashes, etc. The amount of detail revealed by this method of lighting is most remarkable. It is sometimes necessary to use a second 1000-watt lamp, placed about ten feet from the patient, to break up heavy shadows. This lamp is employed "flat." It is placed parallel with the camera and its rays are at right angles to the patient, which is just the reverse of lateral lighting. The second lamp is so far from the patient that it lightens the heavy shadows without destroying the detail shown by the lateral light.

ATTEMPTS AT RADIOGRAPHIC MOTION PICTURES

The history of attempts to make X-ray motion pictures dates back to 1897. In that year, Dr. MacIntyre experimented with different methods of getting successive rapid exposures in recording various movements within the body. These experiments, it must be remembered, were in the very early days of both the motion picture camera and Roentgen rays. Dr. MacIntyre succeeded in making a forty foot reel showing the movement of the joints in a frog's leg. Since 1897 countless experiments have been made in the indirect manner, which is photography of the fluoroscopic screen, and the direct manner, such as exposure of the motion picture film with Roentgen rays.

It is not the intention of this paper to give a history of the experiments that have been made, but to comment on the difficulties yet to be overcome.

Direct Roentgen photography is complicated by the fact that Roentgen rays are not refracted by ordinary lenses. Indirect Roentgen cinematography would seem to offer the largest field for experimentation. However, the inefficiency of fluorescent screens requires great Roentgen energy, which limits application to a few seconds. The records obtained are not of sufficient duration, nor do they always have good definition. What seems to be needed is a greater intensity of the "light" source, faster

films, and better protection for the patient. The present opinion is, that little is to be hoped for from improved fluorescent screens. However, German workers have shown considerable progress in the last few years.

Dr. Hans Jarre of the Grace Hospital, Detroit, Michigan, has brought out a camera called the "Cin-ex" with which he and his associates have done a great deal of good work. This camera is used in conjunction with standard radiographic equipment. The "Cin-ex" uses X-ray film in the form of a long band, which comes in three widths. The band is fitted with a paper leader strip to facilitate daylight loading. It is motor driven and can make three or four exposures per second. A lead diaphragm determines the size of the film to be exposed. The "Cin-ex" automatically brings a

FIG. 1

fresh film surface into position, clamps the intensifying screens in place, makes the exposure and winds the film, exposing a fresh surface for the next exposure. A fluoroscopic screen is also used in the camera, being viewed by a mirror. This of course is not cinematography, but motion pictures can be made from the finished film strip. The "Cin-ex" camera represents a definite forward step in studying the movements of the bodily organs.

The editor of this department wishes to take this opportunity to thank Dr. Jarre for his co-operation in furnishing information. He would also appreciate any additional information or suggestions that readers might supply.

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MAKING OF MOTION PICTURE TITLES

There are a number of ways in which motion picture titles can be made quickly and easily. Some methods give very good results, but these usually take the most time to prepare.

One of the easier methods is to use a slotted board covered with black felt, and movable celluloid letters. This type of board is often seen in restaurants. Titles made in this manner lack a finished appearance, especially if the film is slightly over-exposed, because over-exposure shows up the slots into which the letters fit.

Another rapid method is the use of a regular title stand. Bell and Howell, and the Eastman Kodak Company, both, make such title stands for 16 mm. film. Either white or black title cards may be employed. The white card is sometimes used with a typewritten title. While this is very easy to do, it should be discouraged as much as possible; because, if reversible film is used, the glare of the white card on the projection screen is most unpleasant. This method works much better on positive motion picture film, being used in the negative form on the screen. Care must be used in typing the card to get a black, clean impression of the letters. Hand lettering with white ink on the black cards does very well for rapid work if the lettering is well spaced and neatly done. Remember that slight defects in spacing and forming letters are magnified many times when the film is projected.

Using white, gummed paper letters allows the use of a wide variety of backgrounds. The background is mounted on a card and the letters stuck in position. This method is very neat and effective when carefully done.

Printing the titles with a proof printing press gives the most satisfactory title. Bold face type must be used, otherwise the titles will not stand out. The titles are photographed on positive motion picture stock, and are projected in the negative form, giving a black background with white letters. The film must be placed in the camera with the glossy side to the lens so that the projected negative can be read in the right order. There is no better method than this one, for giving a clear readable title without an amateur appearance.

A few words of warning about making titles. Strive for simplicity, and use as few words as possible to explain the action of the picture. A long title usually makes a bad "break" in the film continuity. Keep the lettering in the same proportion as the frame of the film. Do not crowd the words, as this makes the titles hard to read. Try not to have too many words on a line. Above all do not use too much or too little film footage in a title. A rough way of estimating the footage length of a title is to start the camera, read the title rapidly through twice while the film is running through, and then stop the camera. This usually gives a title of the proper projection time, so that both slow and fast readers have time to read the title. For further information refer to "Title Making and Editing Your Ciné-Kodak Films" by Eastman Kodak Co. and "The Making of Motion Picture Titles" by J. I. Crabtree and C. E. Ives in the *Transactions of the Society of Motion Picture Engineers*, No. 18, pp. 223–34 (1924).

ACTIVITIES OF THE ASSOCIATION

THE CONVENTION

The third annual convention of the Biological Photographic Association was held on September 14th, 15th, and 16th at Powers Hotel in Rochester, New York. This, undoubtedly, was the most successful convention in the history of the Association. The papers were not only interesting but most instructive.

At the close of the convention there was a general feeling among the members that more worthwhile information was given in a shorter period of time than they had expected to be possible. From time to time the papers that were read will appear in this JOURNAL. The complete program was as follows:

THURSDAY MORNING, SEPTEMBER 14, 1933

8:30– 9:30 a.m.	Registration.
9:30–10:00 a.m.	President's Address. Mr. Ralph P. Creer, Edwards Hines Jr. Center. Hines, Illinois.
10:00–10:15 a.m.	"The Photographic Department of the Non-Teaching Hospital." Miss Helen Hanson, St. Francis Hospital, Wichita, Kansas.
10:30–10:40 a.m.	"Photography of the Oral Cavity." Mr. Wm. F. Payne, State Institute for the Study of Malignant Disease, Buffalo, New York.
10:40–11:00 a.m.	"An Epochal Advance in 16 mm. Cinematography." Mr. Harris B. Tuttle, and Mr. A. W. Fuchs, Eastman Kodak Company, Rochester, New York.
11:10–11:30 a.m.	"Direct Focusing of the Motion Picture Camera with a Nasal Pharyngoscope." Mr. Oscar Richards, Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.
11:35–12:00 n.	"Macrophotographic Apparatus." Mr. Carl D. Clarke, University of Maryland, Baltimore, Maryland.

THURSDAY AFTERNOON, SEPTEMBER 14, 1933

Bausch & Lomb Optical Company

12:45 p.m.	By courtesy of the Bausch & Lomb Optical Company, members and guests of the Association were transported to their plant via taxicab.
1:15 p.m.	Luncheon. "Welcome." Mr. Herbert Eisenhart, Managing Director, Bausch & Lomb Optical Co., Rochester, New York.
2:30 p.m.	Tour of the Bausch & Lomb factory.
4:00 p.m.	"Photographic Lenses." Mr. A. A. Cooke, Bausch & Lomb Optical Co., Rochester, New York.
5:00 p.m.	Members and guests were returned to the Powers Hotel via taxicab.

THURSDAY EVENING, SEPTEMBER 14, 1933

Powers Hotel—Spanish Room

7:00 p.m. Business Meeting.

FRIDAY, SEPTEMBER 15, 1933

Eastman Kodak Company

9:00 a.m. By courtesy of the Medical Division, Eastman Kodak Company, members and guests of the Association were taken to Kodak Park via taxicab.

9:45 a.m. Auditorium—Kodak Research Laboratories.

The following papers were presented by members of the Staff of the Kodak Research Laboratories.

"Modern Darkroom Practice." Mr. Glenn Matthews.

"Speed, Contrast and Density." Dr. Lloyd Jones.

"Three Color Photography." Dr. M. W. Seymour.

"Infra-Red Photography." Dr. W. Clark.

"Radiographic Research in the Kodak Laboratories." Mr. R. B. Wilsey.

12:45 p.m. Close of papers and discussions.

INTERMISSION

1:15 p.m. Luncheon—Kodak Research Laboratory Cafeteria.

"Welcome." Mr. Frank W. Lovejoy, Vice-President and General Manager, Eastman Kodak Company.

2:15 p.m. A group photograph was made on the steps of the Research Laboratory. Copies will be mailed to all.

2:30 p.m. Trip through Kodak Park.

3:45 p.m. Inspection of Kodak Research Laboratory.

4:30 p.m. Assemble in Auditorium for final discussions.

5:00 p.m. Return to Powers Hotel. Taxicabs were provided.

FRIDAY EVENING, SEPTEMBER 15, 1933

Powers Hotel—Spanish Room

7:00 p.m. Annual Banquet of the Biological Photographic Association and Election of Officers.

SATURDAY MORNING, SEPTEMBER 16, 1933

Powers Hotel—Spanish Room

9:00– 9:40 a.m. "Some Interesting Motion Picture Technic." Mr. Heinz Rosenberger, Rockefeller Institute, New York City.

9:50–10:30 a.m. "Various Types of Eyepieces Used with the Microscope." Mr. L. V. Foster, Bausch & Lomb Optical Co., Rochester, New York.

10:40–11:20 a.m. "Photomicrography with the Finlay Process." Mr. Jean Kiefer, Norwich State Sanitorium, Norwich, Conn.

11:20–11:50 a.m. "The Scope of Medical Art and Photography at Marquette University School of Medicine." Mr. Leo C. Massopust, Marquette University School of Medicine, Milwaukee, Wisconsin.

12:00–12:15 p.m. "The Rôle of the Medical Illustrator." Natt C. Jacobs, Department of Anatomy, University of Rochester Medical School, Rochester, New York.

In addition to this program, there were numerous photographic exhibits, occupying two rooms and a large hall, making it possible for the members to inspect the type of work that is done in institutions other than their own.

This convention was so successful that immediate plans are being made in advance for the 1934 convention, which will be held in September. Notice is given at this time so that you will have the opportunity to prepare a paper to be read or an exhibition of your work at this meeting.

For further information write to the Secretary of the Association, whose name and address is as follows:

ANNE SHIRAS,
Department of Photography, Magee Hospital, Pittsburgh, Pa.

THE PRESIDENT'S ADDRESS*

Fellow Members of the Biological Photographic Association and Guests:

For the second time within two years I am facing the members of the Biological Photographic Association, and its visiting guests, as its president, and, as is customary in conventions of this kind and character, the president is supposed to bring a message of interest to all the members thereof.

To many of you the brief history of this Association is well known. However, for the benefit of those present who are not familiar with its history, it may not be amiss to say a few words in this connection.

In response to a series of circular letters sent out to men and women directly engaged, or interested in, biological photography and situated primarily in the east, a group of 28 people met at the Yale University School of Medicine on September 11, 1931, and banded themselves into a permanent organization, known as the "Biological Photographic Association." Having started with a charter membership of twenty-eight, representing seven eastern states, we increased our membership the first year to about 90, representing 18 states. Today we have a total membership of more than one hundred and thirty-five, representing 28 states, Canada, and Mexico, and other

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* Delivered at the September 1933 Convention.

foreign countries. The Association was hardly a year old when a journal—the only one of its kind in existence—containing articles of special interest to the biological photographers, was published under the able editorship of Carl D. Clarke of the University of Maryland. The Williams & Wilkins Company of Baltimore takes care of the production end of this journal.

The purpose of the Biological Photographic Association is to further the study of photography in relation to the biologic sciences and to improve its technique. It is by no means a professional union organized to set price standards, or to dictate in any way to its members. It is truly a scientific society, made up of persons directly engaged in, or interested in this field, endeavoring to establish certain standards of quality, and to elevate those standards to the highest degree.

Not long after the organization of our association, I received a letter from Mr. C. E. Anderson, associate editor of the "Camera," who was very much interested in the movement. In his letter he gave, or cited briefly, the history of two similar organizations. In short, they came into being, functioned actively in the beginning, holding meetings at which prominent persons spoke and delivered papers; but as the years progressed, internal complications arose and meetings were abandoned in one organization; while the other was absorbed by the Photographers' Association of America.

While the data on such organizations may seem immaterial in that the intents and purposes of our association may be slightly different, nevertheless we may profit by the examples of other societies preceding us. As far as internal complications and dissensions in our ranks are concerned, I feel safe in saying that such obstacles will never wreck our organization or impede our progress. However, our association was hardly born when it was suggested to me that it might be wise for us to become affiliated with some older and already established photographic society, thereby eliminating some of the difficulties which are attached to every new organization. Although the road has been a little rough at times, nevertheless we have completed two successful years as an independent society, and I can see no reason why we should become attached to any other association.

In my message to you of last year, I stated that on account of the many members located in the central and western part of the country, from a practical standpoint, it would be advisable to establish chapters in these sections of the United States. Inasmuch as I am now situated a short distance from Chicago, Illinois, I have contacted several of our members in this vicinity in regard to this plan. We have collected some fifty names of men and women engaged in biological photography who are not members of our association. With the sanction of this association, I would respectfully suggest that we send out circular letters to these people and proceed to organize a mid-western chapter, not separate and distinct, however, from the parent organization; the main advantage being that it will enable them to get together for the exchange of ideas and information more frequently and at less expense.

With the beginning, or the organization, of any new society, there are of course a great many problems to be overcome, and the tendency is to let a few people do most of the work. The co-operation which I have received from the officers and directors, and which they in turn have received from the members, has been very fine; without such splendid co-operation we would not have advanced as rapidly as we did. However, if we, as an association, are to continue to grow and expand, there must

be an even better co-operative spirit between the officers, the directors, the members in general, and lastly, but by no means least, Mr. Clarke, editor of our journal. For example: in the March issue of the journal was an editorial announcing the fact that the association was undertaking the organization of a number of traveling exhibits; these print exhibits were to be made up of work done by the members of this society and circulated among the people who are interested; the editorial requested that all members send in samples of their work, and that those wishing to receive the exhibits would write to the secretary. I regret to say that to my knowledge little co-operation in this matter was received. I know very well that it is not because you are uninterested in seeing what other people are doing in biological photography, or because you did not care to send in material to be exhibited. It's probably the case of "passing the buck," or "let George do it," and I might add that I plead guilty to these charges. We still intend to carry out the idea of the print exhibit. I wish that when you return home, each one of you would look up the March issue of our journal; read the details; consider them carefully; and then make up your mind to do your part in carrying out this splendid idea. In addition let me add that whenever you receive a request or communication of any kind from the officers, the editor of our journal, or any of our committees, please make a special effort to lend your prompt co-operation to the subject matter, to the best of your ability. Only in this manner can we carry out to the fullest, the aims, ideals and aspirations of our association. In keeping with the prevailing spirit of progressiveness, advancement and recovery, let us strive to make the coming year most successful and helpful. I propose a membership drive. If each individual will be responsible for bringing into the society at least one new member, we will more than double our membership and consequently double the strength of the Biological Photographic Association.

We have in store for us today, tomorrow and Saturday a most interesting and instructive program. I know that we shall all leave Rochester inspired with the new ideas and methods which we are about to see and hear.

In conclusion, permit me to express on behalf of the Association our sincere and deep appreciation to our hosts, the Eastman Kodak Co. and the Bausch and Lomb Optical Co., for the splendid program they have arranged for us. We also appreciate help received from the Rochester Convention and Publicity Bureau. We are especially indebted to Mr. Arthur Fuchs who has done much, and has given a great deal of time and thought, in order that this convention might be a success. My sincere wish and desire is that the Biological Photographic Association will grow bigger and better year by year, and that every member thereof will profit and share in such growth. I thank you.

RALPH P. CREER.

Book Reviews and Abstracts

All books or articles to be reviewed must be sent to Mr. C. B. Neblette, care of Eastman Kodak Company, Rochester, New York

Beginning with the next issue, this department will be conducted by Mr. C. B. Neblette, a member of the Eastman Kodak organization, and the faculty of the School of Photographic Technology, Rochester Athenaeum and Mechanics Institute. Mr. Neblette was formerly the director of the Division of Photography, The Pennsylvania State College; and later a member of the faculty of the Texas A. & M. College. His book, *Photography, Its Principles and Practice*, is one of the most outstanding works on this subject.—THE EDITOR.

Commercial Art and Retouching for Advertising. 72 pages, 47 illustrations and diagrams; price, $1.00. Published by Commercial Art Studio, Cleveland, Ohio. Sold by Paasche Air Brush Company, Chicago, Illinois.

This book should be of particular interest to the biological photographer as it is one of the very few publications that deal quite fully with the air brush for retouching photographs. It gives working instruction in such a manner that the photographer who has little actual art ability can profit by such instruction toward improving his photographs by retouching. It also gives simple techniques for producing other commercial illustrations.

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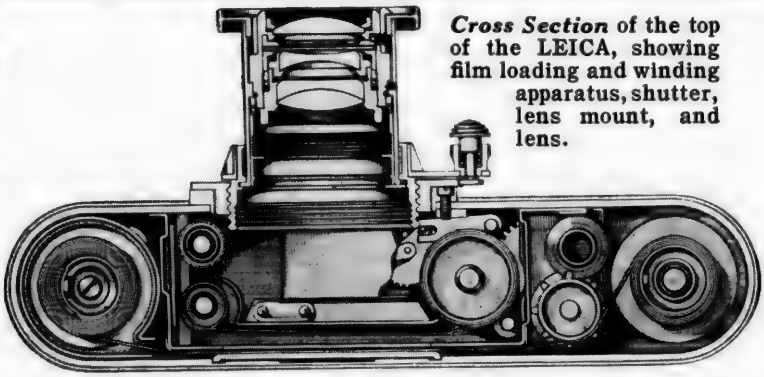


Cross Section **of the top of the LEICA, showing film loading and winding apparatus, shutter, lens mount, and lens.**

VOLUME II *March, 1934* NUMBER 3

The Journal of the Biological Photographic Association

EDITORIAL

THE USE OF REFERENCE

Many photographers do not fully understand how to use references to scientific articles, nor realize the real value of them. Often they think of an idea as to how to build a piece of equipment, or how to go about developing a process, then blindly follow their own plans without making an effort to study the literature already written on the same subject. This often proves to be a waste of time and money. Before attempting to develop anything of importance, it is best to do some research into the scientific literature on the subject in mind.

Let us consider a specific case in which a costly mistake was made by a biological photographer. He thought of an idea as to how to build a cine-photomicrographic outfit, but made no attempt to find out what had already been developed along similar lines. After working for some weeks and spending over a hundred and eighty dollars, he was shown an article that discussed the construction of such devices as he was attempting to build. This article also contained references to other articles on the same subject. He was so impressed with the first article that he obtained the others. After studying them, he realized that his own apparatus was inferior to many that had been discussed in the literature. Furthermore, he came to the conclusion that, had he reviewed these articles before attempting to make his own apparatus, he would have been able to build a far superior piece of equipment. The outcome of the situation was that he dismantled the product of his own mind and began again along different lines, incorporating his own ideas with the

principles that were laid down by previous workers. Unfortunately, his mistakes had cost considerable time and money.

Beginning with the March 1933 issue of this journal, there was published a list of references to scientific articles on photography that appeared in the medical literature. This list was finally completed in the December 1933 issue. Many articles appearing in this, as well as in other journals, have a list of references or bibliographies of the same subjects at the end of the articles. Such references should prove to be invaluable sources of information and inspiration for persons who desire to develop new ideas and equipment. They also should be of great value to authors who are preparing manuscripts for publication.

CARL D. CLARKE.

INFRA-RED PHOTOGRAPHY*

WALTER CLARK

From the Kodak Research Laboratories

The ordinary photographic plate is sensitive to light from a wave-length of λ2500Å in the ultra-violet to about λ5400Å in the blue-green. The short wave-length limit is determined by the absorption of the ultra-violet by the gelatin of the emulsion; the long wave-length limit is set by the limit of absorption of the silver bromo-iodide which constitutes the light-sensitive medium. By the addition of dyes during manufacture, or by bathing the finished plate in dye solutions, it is possible to extend the spectral region to which the plate responds. The region of sensitivity thus added corresponds approximately with the spectral absorption region of the dye. Thus, by the addition of the dye erythrosine, which absorbs the yellow-green, it is possible to make a plate sensitive to yellow-green light, in addition to the ultra-violet, violet, and blue. It was in this way that the so-called orthochromatic plates and films were made. The present orthochromatic materials, exemplified by Verichrome film, are made in a similar way, except that new and more efficient dyes are employed.

By the discovery of certain dyes early in this century, it was found possible to extend the sensitivity of plates and films right through the visible spectrum, including the red. Materials prepared in this way are known as panchromatic materials. The recent advances which have been made in the speed and color sensitivity of panchromatic films and plates are due to the discovery of new classes of very efficient sensitizers.

For many years, experimenters have been interested in studying the region known as the "infra-red," lying between the visible spectrum and the long wave-length heat waves. Various physical instruments, such as the thermopile and the bolometer, have been employed successfully in the investigation of this region. The photographic plate, however, possesses a number of advantages over instruments of this type. It is possible to give it long exposures, so that it can go on building up an impression of a very faint subject. Moreover, it provides a record in a permanent form which can be studied and measured, and which can be stored for further reference. There is little wonder, then, that many

* Received for publication Dec. 15, 1933.

attempts have been made to make the plate sensitive to infra-red radiation.

Over fifty years ago Abney succeeded in doing this by means of a special form of silver bromide dispersed in collodion. He was enabled to photograph the sun's spectrum to a wave-length of 9867Å. His method, however, is not very practicable. Very few workers have been able to reproduce his results, and his plates were very slow, requiring long exposures.

The success attending the use of dyes in sensitizing plates to the visible red led investigators to feel that it might be possible to find dyes which would enable them to extend the sensitivity into the infra-red—i.e., to beyond the visible limit, which is at about 7600Å. Many attempts were made, with varying degrees of success, but it was not until the discovery of Kryptocyanine at the Bureau of Chemistry in 1919 that it was possible to make plates sensitive to the infra-red generally available. This dye has its maximum effect at 7500Å and its sensitizing power extends to about 8000Å. It was used in the preparation of the well-known "Extreme Red Sensitive Plates" and "Panchromatic K Film."

The next step came when Neocyanine was discovered in the Kodak laboratories in 1925. It gives its maximum sensitizing at 8200Å, and with it, spectral lines were recorded to beyond 11,000Å. Its sensitizing power is low, however, and it requires long exposures. Up to the end of 1931, nevertheless, it was the best sensitizer known for the far infra-red.

Recently, as a result of work in Germany, England, and this country, an entirely new group of dyes has been made available as sensitizers for the infra-red, and they have opened up a whole field for study which has already created considerable interest. They are known as tricarbocyanines. They have enabled a series of satisfactory infra-red sensitive plates to be prepared commercially, and have permitted easy photography of the spectrum to a wave-length beyond 12,000Å.

The three most interesting of them give their maximum sensitizing at wave-lengths 8200, 8600, and 9600Å (Fig. 1). These plates have proved of inestimable value to physicists and astronomers. By their aid hundreds of new spectral lines have been discovered, carbon dioxide bands have been found in the atmosphere of Venus, and ammonia has been identified in the atmospheres of Jupiter and Saturn.

Considerable use, however, has been made of infra-red plates for nor-

mal photography. One of the best known of these uses is long-distance photography through hazy atmospheres. When a distant landscape is photographed on an ordinary plate or film, the distance appears hazy, and a slight amount of mist in the atmosphere causes an absence of detail in distant objects, even if they are visible to the eye. This is because

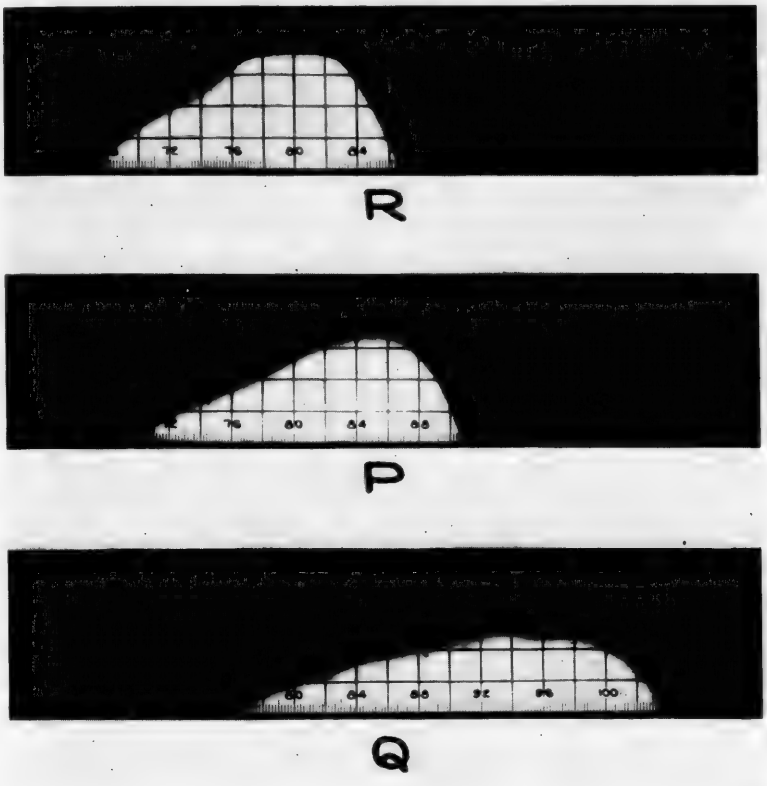


FIG. 1. WEDGE SPECTROGRAMS OF R, P, AND Q TYPE SENSITIZINGS

water vapor suspended in the air scatters the short wave-lengths of light to which the ordinary non-color sensitive plate or film is most sensitive. The plate sees the distant objects as through a fine ground-glass window. The eye has very little sensitivity to these short wave-lengths, and the scattering is, therefore, not so apparent visually. The water vapor, on the other hand, is transparent to the longer wave-lengths of light.

As the water vapor condenses to larger particles, forming a mist or fog, the selection of the longer wave-lengths increases, and more and more of the shorter wave-lengths are scattered. For this reason the sun or an electric street lamp, viewed through a mist or fog, appears red.

It is obvious, then, that if we wish to take a photograph through a mist, or at long distances through a hazy atmosphere, we must use a plate or film sensitive to the longer wave-lengths, in conjunction with a filter which does not transmit the scattered shorter wave-lengths which blur the distant objects in the photograph. An infra-red sensitive plate or film used with a deep yellow or a red filter is particularly suitable. It was by the use of such a combination that Professor Wright was able in 1924 to photograph the Yosemite Valley from Lick Observatory, 120 miles away; Captain Stevens of the U. S. Army Air Corps was able to photograph the peak of Aconcagua in the Andes from an airplane 310 miles away; and last year he was able to take a picture showing Mount Shasta to a distance of no less than 331 miles. The Aconcagua photograph was of special interest in that it showed the line of haze over the Pampas as curved, owing to the curvature of the earth. The limit of the range of the camera is that fixed by the curvature of the earth and the size of the object photographed.

There is a considerable amount of infra-red radiation from the sun, a fact which enables these outdoor photographs to be made. The artificial light sources, however, such as the carbon arc and the incandescent tungsten lamp, emit infra-red rays in relatively considerable quantities, and they are therefore very convenient sources for infra-red photography in the studio.

The yellow or red filter mentioned for use in infra-red landscape work is necessary in order to cut out the short wave-length radiation to which the plate is sensitive. An infra-red plate is sensitive to the normal region in the violet and blue, as well as to a rather limited region in the infra-red. Any filter which has its cut in the spectral region between these two will be satisfactory for use, and the filter factors of all will be the same, provided they do not cut out any of the infra-red rays to which the plate is sensitive. The plate most suited for general infra-red work is that having the characteristics of the Eastman Infra-red Sensitive Plate, Type 1-R, and filters satisfactory for use with it are the Wratten filters, Nos. 15, 25, 29, 70, 89, and 89A. The No. 25 is the most used.

The limit of visibility of the eye on the long wave-length side is at

about 7600Å. If, therefore, we had a plate sensitive to wave-lengths longer than this, and a source of radiation such as a tungsten filament lamp which emits plenty of infra-red rays, and screened by a filter transmitting no radiation of wave-length below 7600Å, we should be able to take photographs in total darkness. This has been done on a number of occasions, both single portraits and pictures of large groups having been made. Further, photographs have been taken in the dark using as the source of radiation hot bodies run at a temperature so low that no visible rays were emitted. A hot body, such as an electric flatiron, is visible in a darkened room if it is heated to a temperature of 500°C. If its temperature is 600°C. it is visible as a dull red body even in a lighted room. At 400°C., however, it is quite invisible in the dark after long adaptation of the eye. At this temperature, it is possible to photograph the iron in the dark, using the short wave-length heat rays emitted by it. We have, in fact, been able to photograph a bust in the dark, using the heat rays from two flatirons, the exposure on a Type 1-R plate being 1 hour at f/4.5. By making photographs on infra-red plates of hot bodies in the dark, it is possible to study the distribution of heat radiation from their surfaces. This has been done, for example, in the case of flat-irons, hot plates, insulated and non-insulated high temperature steam lines, and hot ingots from the steel mill. There is the possibility here of the development of a field of photographic thermometry analogous to that of photographic photometry. In the photography of hot bodies at these relatively low temperatures it is not necessary to use a filter, because they emit no violet or blue light.

When a photograph of an object is made, "illuminating" it, as it were, by infra-red rays supplied by a light source and a filter, the success of the photograph depends on the way in which the object reflects or transmits the infra-red. Much is known about the way in which materials reflect or transmit visible light. The advent of infra-red photography, however, showed that we knew relatively little about their characteristics as far as infra-red radiation was concerned. Much information has been obtained by actually making infra-red photographs, although there is still a wide field for study here.

In infra-red photographs of landscapes containing trees or grass, the leaves and grass are rendered as white owing to the high reflecting power of chlorophyll for the infra-red. Chlorophyll has a sharp absorption band in the far red at λ6700Å, but it reflects freely at wave-lengths beyond λ6800Å (Fig. 2).

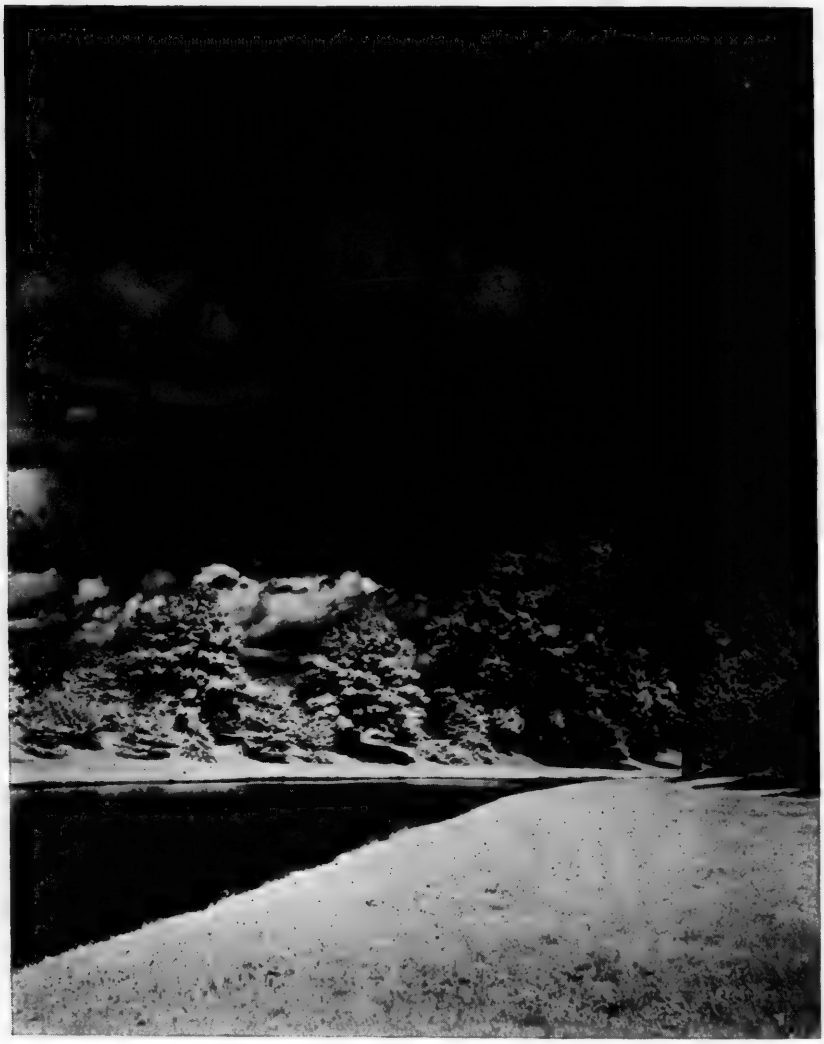


FIG. 2. INFRA-RED LANDSCAPE PHOTOGRAPH

The foliage of coniferous trees does not appear to reflect the infra-red as well as does that of deciduous trees, and it is generally possible to distinguish readily in an infra-red photograph between conifers and deciduous trees, even if their shapes are not discernible. There are variations among the deciduous trees which indicate that it might even

be possible to distinguish between species. The distinction between the various conifers is much less. At the School of Agriculture at Cambridge, England, infra-red photography has been applied to the study of the "streak" diseases of the potato. With normal panchromatic plates it is difficult to show up necroses occurring in the dark green leaf. Unless the necrosis is extensive, the pictures look like those of healthy leaves. Using infra-red sensitive plates, however, high contrast is obtained between the leaf and the necrosis. The necrotic areas do not reflect infra-red, and therefore appear dark in the photograph. All necroses in the potato behave similarly regardless of the causative virus.

In the case of necroses in tobacco caused by the "X" virus, the results are opposite, good photographs being obtainable on panchromatic plates, while those on infra-red plates show no contrast and resemble healthy leaves.

This difference is probably due to the different chemical structure of the necroses. The panchromatic plate distinguishes between color changes, while the infra-red plates distinguish between chemical differences.

Woods vary considerably in their absorption of the infra-red, although most varieties in thin sheets are transparent.

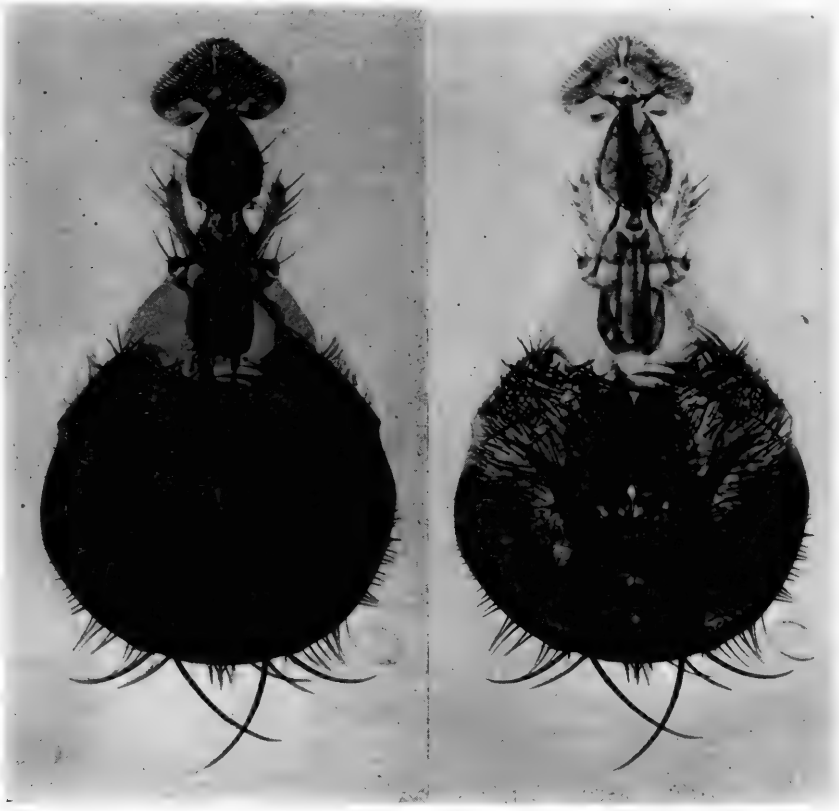
Stains and pigments vary greatly in their behavior to infra-red, and the way in which they reflect visible light bears no relation to their behavior towards the infra-red. For instance, if an infra-red photograph is made of a Winsor & Newton chart of oil colors, the colors of which cover the whole visible range, they will all render light in the photograph with the exception of the iron blues, greens, and blacks which absorb infra-red and are rendered dark. Similarly dyed fabrics show very varying results; many cloths which appear very dark to the eye reflect the infra-red strongly and appear light in a photograph. Carbon black is very opaque to the infra-red.

Inks vary in their absorption of the infra-red. It is due to this fact that Dr. Bendikson, of the Huntington Library and Art Gallery, was able to decipher the copy of De Bry's Voyages in which passages had been deleted in ink by the censor of the Spanish Inquisition.

Dr. Bendikson has also succeeded in deciphering documents so badly charred by fire as to be illegible, while at the British Museum ancient texts too faint to be read have been deciphered by infra-red photography. It has been found possible also to reveal the original drawings in the case of engineering tracings, parts of which had been erased. This method

may, therefore, prove a valuable tool in the hands of the bibliographer and the examiner of questioned documents.

Infra-red radiation has been used successfully for photomicrography, especially with some specimens which are deeply colored, such as insect preparations. Such photographs show the internal structure as well as the detail of the exterior (Fig. 3).



a *b*

FIG. 3. PHOTOMICROGRAPH OF HEAD OF BLOW-FLY, (*a*) BY GREEN LIGHT, (*b*) BY INFRA-RED. MAGNIFICATION, ×15

It is not likely that infra-red photography will be of much value for the photomicrography of stained specimens, since all ordinary stains are completely transparent to the infra-red. Its use will probably be confined to specimens having a considerable amount of absorption, and therefore to low magnification work.

The way in which the skin and flesh reflect and transmit the infra-red is of considerable interest, and it is possible that in the medical field infra-red photography will prove of considerable value. In an infra-red portrait the

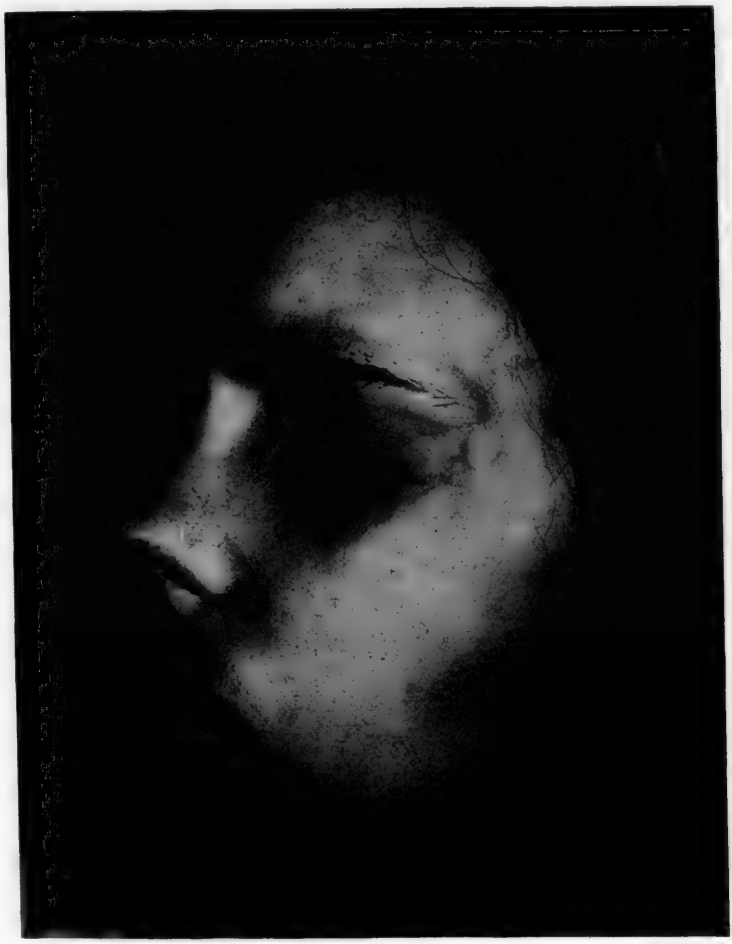


FIG. 4. PICTURE OF GIRL'S FACE

The vein by the side of the eye was scarcely visible. The girl was of dark complexion.

flesh appears chalky, the red lips come out very light, the eyes appear as small black circles, the hair usually renders light, and all lines in the face are exaggerated (Fig. 4). Negroes tend to photograph light.

A study of the skin by infra-red photography may reveal many things which are not apparent to the eye nor in a normal photograph. In Copenhagen, cases of lupus have been photographed by infra-red, the photographs distinguishing between dead skin and tissue and living skin with lupus nodules in it. Varicose veins not perceptible to the eye have been clearly shown in infra-red photographs. In the St. Goran Hospital in Stockholm, Sweden, and in other hospitals in Europe and this country, infra-red photography is used for the study of skin diseases and the blood vessels, revealing troubles not visible to the eye and touch, and not shown in a normal photograph.

A certain, but inadequate study has been made of the penetration of infra-red radiation through flesh. That there is some penetration is clear from the use of "radiant heat" for therapeutic purposes of internal heating. Cartwright, at the California Institute of Technology, showed that the cheek, and bacon fat, transmitted the infra-red between 7000 and about 14,000Å, the maximum being at about 11,500Å. The cut-off at about 14,000Å is due to absorption of the radiation by the water in the body. There is considerable scattering of the infra-red by the flesh, although there is evidence that this diminishes with increasing wave-length.

These considerations led to the thought that some results of value might be obtained by photography of parts of the body transilluminated by infra-red. It is well known that if the hand is held up in front of a bright source of light, red light is transmitted through it, and a photograph of the hand can be obtained in a darkened room by this transmitted light. Such a picture shows little or nothing of the internal structure of the hand, owing to the scattering action of the flesh. Using infra-red plates somewhat superior results are obtained, some of the internal structure near the surface facing the camera being revealed. It is doubtful, however, whether this is of any more value than a photograph made by reflected infra-red. The subject is worth pursuing further, however. Statements have appeared a number of times to the effect that it is possible to secure shadowgraphs of a hand by infra-red, similar to radiographs. This is not so, however. Although dark areas appear along the middles of the images of the filters, they are not shadows of the bones, and are of little interest.

The transillumination method of visual inspection has been in use some years. In the case of the female breast, for instance, a light is placed behind the breast which is inspected in a dark room by the transmitted

light. The blood vessels, areola and nipples show dark, and so do certain tumors, such as cancer. It is possible to photograph a subject such as this on Supersensitive Panchromatic materials, but the exposures are long. With infra-red materials they are even longer, but there is the advantage of better rendering of detail, and it is possible that a study of this sort of photography by the infra-red would be of value. Discomfort of the patient due to heat could probably be prevented by use of a water cell in front of the lamp.

For photography using infra-red radiation, the most convenient source of light is the usual incandescent tungsten filament lamp. For general purposes the Type 1-R plate, having its maximum sensitivity at λ8200Å is most useful, and any of the following filters may be employed: Wratten filters, Nos. 15, 25, 29, 70, 89, and 89A. If it is desired to take photographs in the dark, the light source itself should be screened with the Wratten No. 87 filter.

Any normal camera may be employed and a normal anastigmat lens is satisfactory. Theoretically, the focus for infra-red light should be very slightly different from that for white light, but in practice, most lenses are satisfactory if focused in white light. If an improvement is desired the pictures can be focused on the ground glass, with the red No. 25 filter on the lens.

Any normal negative developer can be used, although the preferred one is the D-19, X-ray Developer. The darkroom can be illuminated with green light from the Wratten No. 3 safelight. No special precautions are required in storing the Type 1-R plates, although in common with other plates they keep best if maintained cold.

INEXPENSIVE MOTION PHOTOMICROGRAPHY*

H. M. KINGERY

From the Department of Anatomy, School of Medicine, University of Colorado

INTRODUCTION

Comandon ('29) and Patten and Kramer ('32) have emphasized some of the many uses of the motion picture in biological fields and it is therefore unnecessary to dwell on this here. It will be enough to say that there is an increasing number of investigators who are making use of this process in recording the results of their work, and in communicating these results to others. Under this latter head would be included the use of motion pictures in the teaching of classes in the various fields of Biology and Medicine. These motion pictures are both macroscopic and microscopic. The latter are being more and more widely made and used, as is shown in the programs of the American Association of Anatomists for the last few years.

Comandon ('09 and '29) was probably the first to make serious use of cinephotomicrography in his study of living human leucocytes. Since his early work there have appeared descriptions of apparatus for this purpose, constructed and assembled by individual workers, adapted to their individual needs, uses and budgets. Heard ('32a) has given a discussion of a number of outfits which have been used and described in the last few years.

APPARATUS

One thing common to all types of apparatus has been the cost, and of this, the cost of the motor drive is not the least. Desiring to make some films for teaching purposes, we decided to attempt the assembling of an outfit which would come within a very modest budget. The apparatus experimented with is a modification of that described by Bayne-Jones and Tuttle ('27). It has been perfected by Eastman Kodak Company and Bausch and Lomb Optical Company and is now on the market. The complete equipment, however, costs nearly as much as some of those described in the literature, and for this reason was not available. The point to be emphasized here is that one can substitute cranking the camera by hand for the motor drive (which is the most expensive part

* Received for publication June 25, 1933.

of the apparatus), and get very satisfactory results within a somewhat limited field of work.

The camera is the hand-cranked Ciné-Kodak Model A, used without its lens. With this is employed a "beam splitter," as described by Bayne-Jones and Tuttle, and by an anonymous writer in "Photomicrography," which fits in a sleeve attached to the front of the camera in place of the camera lens. Used with this is an amplifier or negative lens to correct for the image distance to the film which differs from that of the microscope in ordinary use. Compensating amplifiers for use with apochromatic objectives can be obtained now although they were not used for making our films. The amplifier takes the place of the ocular in the microscope. In the "beam splitter" is a prism which reflects about 90 percent of the light to the film; the remaining 10 percent passes through to form a visual image with the observation eyepiece which has an etched rectangle indicating the area of the film. When the image is in focus with the ocular it is also in focus on the film. It is thus possible to focus moving objects while operating the camera. There is no device for focusing directly on the film which is a disadvantage under some conditions.

A stand for an old photomicrographic apparatus was used for a camera support. A steel shelf was bolted to the sliding plate originally designed to support the microscope. This plate slides along a steel bar and is held in place with two bolts with large knurled nuts. The bar was raised to a vertical position and fastened in place. To the free edge of this shelf was fastened a leg, adjustable in height. This leg is of two pieces of steel, one attached to the shelf and the other to the heavy cast iron base. By tightening the wing nut on a bolt which passes through a hole in one part of the leg and through a slot in the other, this leg can be set at the correct height for the microscope. A camera screw through a slot in the shelf holds the camera in place. This permits moving the camera backward or forward a slight distance before being fastened when the beam splitter is in correct relation with the microscope. By setting the camera support at such a height that the draw tube of the microscope must be raised a few millimeters to attain the correct tube length, the microscope or camera stand may be adjusted to the correct position and the draw tube then raised and the light-tight connection made. The space between the two legs of the camera support is ample for illuminating the microscope and for the placing of the condensers, water bath, and filters.

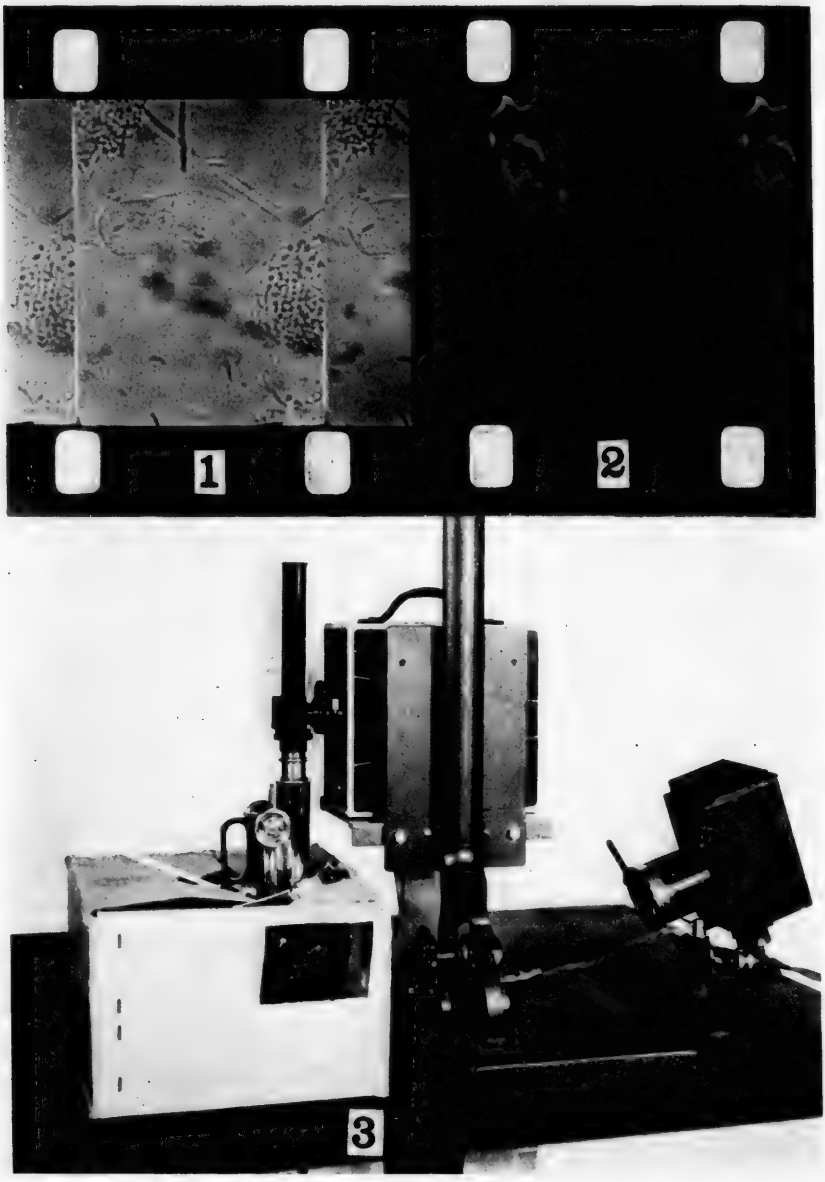


FIG. 1. AMOEBA GINGIVALIS

Photographed with bright field illumination on supersensitive panchromatic 16-mm. reversal film with Spencer 3-mm. apochromatic immersion lens and 3X amplifier. Magnification on the film, 180X. A negative was made on portrait film by enlargement from the positive 16-mm. film (7.5X) and a print made by reduction to 5X. Total magnification, 900X. Reduced in reproduction to 720X.

FIG. 2. NEUTROPHILIC LEUCOCYTE

Photographed by dark field illumination on supersensitive panchromatic 16-mm. reversal film, with Zeiss apochromatic 3-mm. immersion lens "X" and 3X amplifier. Magnification on film, 180X. Print made as in figure 1. Magnification 900X. Reduced in reproduction to 720X.

FIG. 3. GENERAL VIEW OF THE APPARATUS

The electric wire goes to the bulb for heating the warm chamber. The crank is on the far side of the camera. The opening opposite the mechanical stage is ordinarily closed with a hinged door in operation.

For most work with protozoa a warm chamber or incubator is probably not necessary, but is essential for work with tissues and cells of the higher forms. For this work, a warm chamber was improvised from a cardboard box or carton heated with a 50-watt bulb, after an early suggestion by Dr. Sabin. Openings were cut in the flaps of the lid to fit around the microscope; one was also cut in the front of the box opposite the mirror of the microscope, and another on the side to permit operating the mechanical stage of the microscope. By moving the lamp bulb toward or from the microscope in the box the temperature at the slide level can be maintained fairly constant in spite of the several openings in the box. The hole giving access to the mechanical stage was ordinarily kept closed with a flap or door. A thermometer with its bulb just above the slide near the objective was used to check the temperature. A thermostat would maintain a more constant temperature, but there was a surprisingly slight variation in temperature with this simple arrangement.

ILLUMINATION

Several light sources were used depending on the type of object to be photographed. For bright field work at magnifications of 10 to 200 on the film the 6-volt 108-watt ribbon filament lamp gave satisfaction. The intensity of this light is too great for slow picture speeds and may be lessened by the use of the neutral density filters between beam splitter and film, or by the use of similar filters or ground glass between the microscope and the light. Color filters will also reduce the actinic effect of the light, and if properly selected will increase or decrease the contrast on the film, as desired. For absorbing heat rays either a water bath or a solution of copper sulphate was used.

Since direct current was not available, the alternating current arc was tried for dark field work, with varying success. More uniform results were obtained with a 1000-watt projection bulb with reflector and condensing lens. The latter was used for dark field pictures of leucocytes. Fortunately for the success of the film, the more slowly moving lymphocytes and monocytes have less luminous granules, so the slower rate of taking the pictures to speed up their apparent motion on projection gave longer exposures to the film. The more rapidly moving neutrophils and eosinophils with their more luminous granules were also properly exposed with a faster rate of picture taking, and a consequent shorter exposure.

OPERATION

Two tables of the same height are used, close together but not touching, with camera stand and light on one, and the microscope in the incubator on the other. This prevents the transmission to the microscope of vibrations due to the operation of the camera. The apparatus was set near the right hand ends of the tables for convenience in manipulating the various parts. With the beam splitter removed from the camera there is room for the head of the observer and the field can be located and adjusted. The substitution of amplifier for microscope ocular and fitting of the beam splitter can be very quickly and easily done.

The cranking is performed with the left hand. This leaves the right hand free for focusing and manipulating the mechanical stage, etc. A seconds pendulum was improvised from a weight and a string, and the length was adjusted until the period of vibration when compared with a stop watch was found to be approximately correct. When this is supported so that it or its shadow is easily caught by the eye, it is easy to attain and maintain the rhythm of a uniform rate of cranking. Using the crank which is regularly supplied with the camera it is easy to turn the crank at the rate of two revolutions per second (normal speed), one revolution per second, or one every two seconds, thus attaining exposure rates of 16, 8, or 4 per second. With the "single picture attachment" (a crank which gives one exposure for each complete revolution of the crank) exposure rates of two per second, one per second, and one every two seconds are easily obtained. Slower rates have not been attempted as these were satisfactory for work done so far. For such slower rates it would be possible to crank intermittently—one revolution of the single picture crank at any convenient speed to obtain the correct exposure, at any desired interval. The patience and attention of the operator would determine the success of this procedure. A couple of hours might be the limit for this. It is, however, quite simple to maintain a steady rate of exposure ranging from 16 per second to one every two seconds. At the rate of one exposure every two seconds it would require more than two hours to expose 100 feet of 16-mm. film, and this will serve for many subjects. Obviously, for actions requiring many hours for completion, this method is inadequate. There is also available for this camera a "slow motion" crank with which an exposure rate of 64 or 32 per second may be obtained, thus "slowing up" fast motion for analysis.

Two kinds of film are available in the 16-mm. size, regular panchro-

matic, and supersensitive panchromatic, which is three to five times faster with tungsten light than is the regular. The regular will serve for most bright field work while the supersensitive is needed for dark field illumination, and might be necessary for some work by reflected light. There is also on the market a cheaper film (orthochromatic) but the author has not tried it.

With this apparatus, since the shutter aperture is fixed, there are three factors involved in determining the exposure of the film: the speed of the film, the intensity of the light, and the rate of exposure or picture speed. If the action or movement will be best shown by a given picture speed, the proper film is selected, and then the intensity of the light varied to produce the correct exposure. As indicated above, neutral density filters, ground glass, or color filters may be used for reducing the intensity of the light for the slower picture speeds. The solution of copper sulfate will also serve for this purpose. Test exposures are made and the correct lighting conditions for a given object and exposure rate are determined. Data of this sort kept on file will save time in subsequent work. The camera is removed to the dark room and the exposed film developed as a negative (in the dark, as this is panchromatic film). If the film so exposed and developed gives a good negative, the reversal process will yield a good positive.

This method of making cinephotomicrographs by hand cranking is not as accurate in timing as the use of the more complicated equipments employing a synchronous motor drive.[1] This is not, however, so serious a fault as it might seem. In much of the subject material for work of this sort the interest lies in the action itself, the manner in which it occurs, rather than the exact duration of time in which it takes place. More exact methods than the counting of motion picture frames may be used to determine duration of time. The recording of a clock dial in a corner of the film, while very valuable in some cases, is hardly possible with 16-mm. apparatus. But even the best equipment available for this work is not absolutely accurate. Heard ('32a) says "the problem of *exact* time lapse is not adequately solved."

[1] It should be possible to add to this apparatus some form of electric drive of the type described by Loveland ('32, '33) at a comparatively small cost, for photographing actions requiring more than two hours for completion, and a consequent slower rate of picture speed.

COST

In many institutions the cost must be seriously considered. Most of the equipments described in the literature are expensive to assemble and are out of the reach of a modest budget. The cost of the apparatus described here is low. Our cost was about $100, as a camera belonging to the Photographic Department of the Medical School was available. We have since obtained a used camera for $50. A new camera, without lens lists at $125. The camera stand was improvised from old equipment, the only expense being the cost of materials, which was less than a dollar. The incubator or warm chamber cost nothing.

The cost of operation for a 16-mm. camera is much less than for 35-mm. apparatus. The cost of 35-mm. materials and their processing seems to vary. Heard ('32b) gives the cost of a finished positive as slightly less than $.05 a foot, and Dubray and Mitchell ('31), as $.10 to $.15 per foot. Locally, the prices a year ago were from $.07 to $.11 per

TABLE 1

Ciné-Kodak Model A	$50–125
Beam splitter (optical connector) and eyepiece	60
Amplifiers	20
Single picture attachment	20
	$150–225

foot. The cost of the 16-mm. reversal film is $.06 or $.075 per foot. Taking 16 minutes projection time at normal silent film speed for comparison, this means 1000 feet of 35-mm. positive at a cost of $50 to $150, compared to 400 feet of 16-mm. reversal film costing $24 to $30. These reversal film costs are for panchromatic and supersensitive panchromatic emulsions; there has recently appeared on the market a film (orthochromatic) at half this price, but the author has not investigated it. Sixteen-millimeter positives may be made by reduction from 35-mm. negatives for $.10 per 16-mm. foot, making the total cost the same as that of 35-mm. positive (for the same projection time). Furthermore, 16-mm. negative film may be used in the smaller camera and positives printed from them for $.08 to $.10 per foot or $32 to $40 for 400 feet. The cost then of 35-mm. positives is anywhere from two to six or eight times as great as that of the 16-mm.[2]

[2] Thirty-five-millimeter supersensitive or panchromatic number 2 film may be purchased from Warranted Films Inc., 729 Seventh Avenue, New York, N. Y., or

DISCUSSION

It may be rash to compare the qualities of the two sizes of film available for work of this sort. In view, however, of the disparagement of the small film in several recent discussions, the writer thinks it well worth while to point out the value of 16-mm. equipment and film for this purpose. The larger film is without doubt the one to use when the pictures are to be shown in "theater proportions," or when they are made for "production." But for occasions when such large screen sizes are not necessary, the smaller film is satisfactory, either made by reduction from 35-mm. negatives, or made direct on reversal film. Probably most of the films made by cinephotomicrography are shown before relatively small "audiences."

Patten and Kramer rather discourage the use of the 16-mm. film and apparatus "for anything other than the simplest of subjects photographed at moderate magnifications." Heard ('32b) in emphasizing value of the larger film, states: "The quality of the results are not comparable, especially when film resolution and magnification are seriously considered." On the other hand, Tuttle ('32) states: "The resolution obtainable in projected images of 16-mm. and 35-mm. film is about equal."

One of the factors in film resolution is the graininess of the emulsion, and in this respect the reversal film is superior to the 35-mm. film. Hardy and Perrin ('32, p. 236) state:

"Positive emulsions are less grainy [than negative emulsions], but a positive printed from a negative is more grainy than either alone. In other words, the superposition of the grain patterns of the two materials has the effect of increasing the apparent

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Wafilms Inc., 1123 Bronson Avenue, Hollywood, Calif. for two and a half cents per foot. Positive film (35-mm.) may be purchased from the same firms for less than one cent per foot. If the developing and printing—which is comparatively simple—is done by the individuals taking the pictures, the finished 35-mm. negative and positive will cost less than three and a half cents per foot. (See article on page 42, Vol. 1, No. 1 of this JOURNAL.) However if the negative is sent to a commercial laboratory for processing the cost in New York and Baltimore is approximately one cent per foot for developing the negative and three cents per foot for printing the positive. The positive film is included in the cost of printing and is furnished by the laboratories in any desired color. This makes a total cost of six and a half cents per foot for the finished 35-mm. negative and printed positive. Further: 35-mm. negative can be reversed just the same as 16-mm. negative. (See article on page 199, Vol. 1, No. 4 of this JOURNAL.) This will make the finished 35-mm. positive cost only two and a half cents per foot, providing the reversing process is done by the operator and not the commercial laboratory.—*The Editor.*

graininess of the resulting positive. For this reason, direct positives made by reversal, such as the 16-mm. ciné films, will stand a much higher magnification in projection than positives printed from a negative in the ordinary way."

It would seem, then, that the smaller film itself does not suffer in this respect when compared with the larger.

In regard to the projection of the films for teaching or demonstrating the results of research, the smaller films can now be shown very satisfactorily. Until recently, the projectors available have been designed for home use where large screen images are neither desirable nor necessary. The illumination adequate for these small pictures did not permit large screen size. Recently, however, new projectors with more intense illuminating units have appeared on the market, and have made possible the showing of very much larger pictures in a very satisfactory manner. Writing in 1931 when the most powerful light source for 16-mm. projectors was a 375-watt bulb, Dubray and Mitchell say: "16-mm. projectors can now show pictures 8 x 10 feet (and even larger), of sufficient brilliance and quality to be seen comfortably by audiences of one, two, or even three thousand." And this year, projectors with 500- and 750-watt bulbs are available.

A disadvantage of the reversal film is in the making of duplicates. These can, of course, be made from this film, but unless done before the film is projected any great number of times, scratches occur which will mar the duplicate. And, the duplicates are not quite as good as the original film. Negative film can be used in the 16-mm. camera and positives printed as from 35-mm. film, but these are much more grainy than the reversal film.

Dubray and Mitchell ('31) after a comprehensive discussion of the two sizes of film write as follows:

"From the foregoing, we reach several definite conclusions regarding the equipment to be selected for certain definite classes of work:

"First: Where quality is paramount, where many prints are to be made, and the pictures are to be shown to very large audiences: *Then 35-mm. prints from 35-mm. negatives should be used.*

"Second: Under the same conditions, except where the pictures are to be shown to audiences up to, say, 2000 and where the auditorium is not equipped with regulation booth: *Then 16-mm. reduced prints from 35-mm. negatives are indicated.* This combination is also recommended where the highest quality is desired, compatible with portability and ease of operation.

"Third: Where a large number of prints are to be used, where portability and ex-

pense are important considerations: *Then 16-mm. contact prints from 16-mm. negatives are suggested.* These are very satisfactory, in spite of a greater graininess of the prints. The alternative to the above is the use of *16-mm. duplicates from 16-mm. positives.* After making about six to ten duplicates, the cost of this method becomes greater than the use of 16 mm. contact prints.

"Fourth: Where one, or only a few prints are needed, of very good quality, and where expense is the principal item: *Then the use of 16-mm. camera and 16-mm. reversal film is definitely indicated.*"

For the very best results, then, 35-mm. apparatus and film are essential, and will undoubtedly be used when the funds are available. On the other hand, entirely satisfactory work can be done with 16-mm. equipment. As has been shown, the first cost of apparatus and the operating cost is very much less for the film of smaller size. This lower cost, reduced still further by the substitution of cranking by hand for the motor drive, would make this important aid to teaching and research available to institutions, and individuals, for whom the cost of 35-mm. apparatus is prohibitive. This, in turn, should make possible the production of valuable films which might otherwise never be made.

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THE CORRELATION OF MICROSCOPE OBJECTIVES AND EYEPIECES*

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This paper is prepared in an attempt to show how to make the proper selection of microscope eyepieces to use with the standard microscope objectives. The sequence followed will be first, a general and rather elementary discussion of the eyepiece and its function, second, a survey of the microscope objectives in daily use, third, an outline of the optical performance of microscope objectives, fourth, an analysis of the meaning of chromatic difference of magnification, fifth, the *Huygenian* eyepiece and its use, sixth, the *Hyperplane* eyepiece and its use, seventh, the *compensating* eyepiece and its use and eighth, other eyepieces.

An eyepiece for use in a microscope consists of two or more lenses mounted in a tube which fits inside the upper tube part of a microscope and serves the purpose of magnifying the real image formed by the microscope objective. The amount of magnification of the eyepiece is a function of its focal length. Since most microscopists are interested in knowing the magnification they are securing with a given objective and eyepiece it has become almost a universal custom to mark both the objective and eyepiece with their respective magnification factors rather than their focal lengths. Eyepieces are made in focal lengths to give magnification factors from about 5X to 25X. These magnification factors are called, for example, either 5X, 5 times or 5 power.

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Eyepieces, whether they be for a microscope, a telescope or special apparatus are either negative or positive. Negative, applied to an eyepiece means that the focal plane is virtual. In the case of most negative eyepieces the focal plane lies between its lenses. Positive eyepieces always have a real focal plane. This real focal plane is outside the lenses and a real object could be placed in it and be observed by the eye. That is, a positive eyepiece could be used as a hand magnifier, were it not for the tube in which the eyepiece is mounted extending beyond the focal plane. A negative eyepiece cannot be used as a hand magnifier because the focal plane is virtual. If an object is placed between the lenses, the

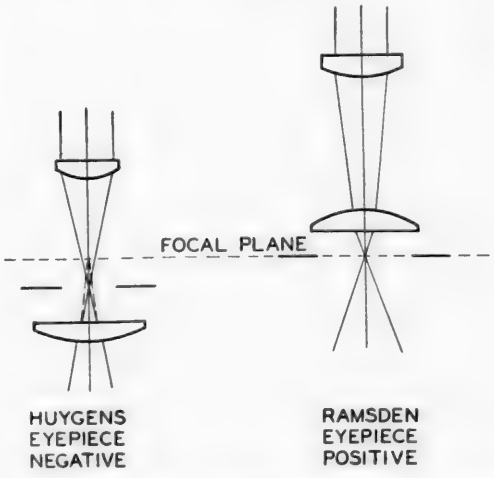

FIG. 1. THE FOCAL PLANE FOR THE HUYGENS EYEPIECE IS BETWEEN THE LENSES

The focal plane for the Ramsden eyepiece is outside of the lenses

collective will have no effect in forming its image and the object might as well be examined by the eyelens alone. Examples of negative eyepieces are the Huygenian and negative amplifiers. Examples of positive eyepieces are *Ramsden, Kellner,* and *Orthoscopic.* Figure 1 shows a negative eyepiece and a positive eyepiece.

Detail differences between these eyepieces will be treated under the subject of *Huygenian* eyepieces, *Hyperplane* eyepieces and *compensating* eyepieces.

Microscope objectives vary in focal length from 48 to 1.5 mm. The long focal length objectives magnify only a few times and the short focal

length objectives magnify many times up to approximately 125 times. The long focal length objectives have low numerical apertures as well as low magnifications and the short focal length objectives have high numerical apertures corresponding with their high magnifications. Figure 2 is a table giving the focal lengths, numerical apertures and magnifications of a broad range of microscope objectives.

The character of the images formed by microscope objectives differs, and depends somewhat on the focal length, numerical aperture and construction. The purpose of the microscope is to give the best possible

Focal Length	*Numerical Aperture*	*Mag.*
Achromatic		
48.0 mm.	0.08	2.0×
40.0 mm.	0.08	2.6×
32.0 mm.	0.10	4.0×
16.0 mm.	0.25	10.0×
8.0 mm.	0.50	21.0×
4.0 mm.	0.65	43.0×
4.0 mm.	0.85	45.0×
3.0 mm.	0.85	60.0×
1.9 mm.	1.25	91.0×
Fluorite		
4.0 mm.	0.85	43.0×
1.8 mm.	1.30	93.0×
Apochromatic		
16.0 mm.	0.30	10.0×
8.0 mm.	0.65	20.0×
4.0 mm.	0.95	45.0×
3.0 mm.	0.95	62.0×
2.0 mm.	1.30	90.0×

FIG. 2. TABLE OF OPTICAL DATA FOR MICROSCOPE OBJECTIVES

image of detail in the object and to faithfully reproduce that detail in shape and color in the image. To this end, the designer of microscope objectives concentrates his attention on reducing spherical and zonal aberration, as well as chromatic aberration, and coma to a minimum. The result of obtaining these corrections for any objective leads to the formation of an image on its optical axis substantially free from haze and color. That is, if there exists as an object on the optical axis of the objective a white dot of finite size, the image will be a magnified white dot substantially free from haze and color. If the white dot object is moved off the axis of the microscope objective it will be found that the best image

will lie closer to the objective than when the dot was on the axis. In other words, the image formed by a microscope objective lies on a curved surface. This quality is called curvature of field and is dependent upon the focal length of the objective, its numerical aperture and its spherical correction. Microscope objectives could be designed to produce flat fields, but only at the cost of definition or resolving power. The long focal length objectives such as the 48- and 32-mm. objectives have relatively flat fields because of their simple construction and small numerical aperture. The 16-mm. object has some curvature of field which is particularly apparent when the object is thin. The other high power objectives have still greater curvature of field, because of their complex lens system which is formed of several extremely short focus lenses and their high numerical aperture.

The front lens element in a microscope objective has the most influence in determining its magnification. This lens may be single, as in high power objectives and is called the hemisphere, or it may be a doublet as in the medium powers. In either case, it is this lens which is the power producing element. The other lenses serve the purpose of correcting the inherent under correction of this lens.

When the variables of the other lens elements are so chosen as to correct the aberrations of the front lens there exists a condition called chromatic difference of magnification. This means that the objective does not have the same focal length for all colors of the spectrum. This must not be mistaken for chromatic aberration, since chromatic aberration is well corrected. Any well corrected microscope objective will have no indication of a colored image in the center of the field. Chromatic difference of magnification is only evident on an object of finite size and becomes more noticeable as the object increases in size or as it is moved to the edge of the field. This difference is always an under corrected difference which means that the focal length for the long wavelengths is longer than for the short wavelengths. In practice this is detected by a larger blue image of a white object than a red image. Strange to say, chromatic difference of magnification is not a fixed quantity for each objective but is dependent upon the power of the objective. Furthermore, it is enhanced by correcting the objectives for secondary spectrum. In other words, chromatic difference of magnification is small for low power objectives, and large for high power objectives. It is also larger for low power apochromatic objectives than for high power achromatic objectives.

Before discussing eyepieces it will be well to understand in general the correction of aberration for any lens or lens system. A lens or a lens system can only be corrected for one object distance and one image distance and the points where the object and image planes intersect the axis of the system are called conjugate image points. The object distance of a microscope objective is pretty well known as its working distance, and the image distance is approximately its tube length. Telescope objectives have an infinite object distance and their image distance is called their back focus. The object distance of an eyepiece is its front focal distance and the image distance is infinite. It should be noticed that in telescope objectives the image is formed at the focal

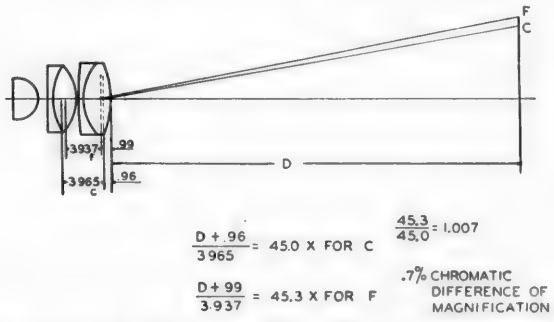

FIG. 3. FOUR-MILLIMETER ACHROMATIC MICROSCOPE OBJECTIVE SHOWING THE POSITION OF THE FOCAL POINTS FOR *F* (BLUE LIGHT) AND *C* (RED LIGHT) AND THE VALUES FOR THE EQUIVALENT FOCAL LENGTH FOR THESE COLORS

The blue image is magnified more than the red image and the ratio of the magnification of the blue image to the magnification of the red image is chromatic difference of magnification.

point and that in eyepieces the object is placed at the focal point. Thus in telescope objectives and in eyepieces achromatism means that they have equal focal lengths for two lines of the spectrum. Microscope objectives, however, have neither their object or their image at the focal point and achromatism of focal lengths is not a result of achromatism for the two conjugate planes, i.e., object and image planes. Achromatism in a microscope objective means that for definite object and image distances the image distance is the same for two lines of the spectrum. The result is that the focal lengths of the two spectrum lines of the microscope objective are different. The image distance for these two spectrum lines are the same but their focal lengths are different and for the

two spectrum lines two images of different size are formed. To understand this we must refer to figure 3 and show how to determine magnification. Magnification may be defined as image distance divided by focal length and since the focal length is different for the spectrum lines the magnification is different and hence the two different size images for the two spectrum lines. This condition is described as chromatic difference of magnification. It is the object of this paper to create a better understanding of the existence of this condition, and to point out how its effects can be minimized by the proper selection and use of the various types of eyepieces.

Figure 4 gives two graphs of the chromatic difference of magnification existing in the available microscope objectives. These differences are

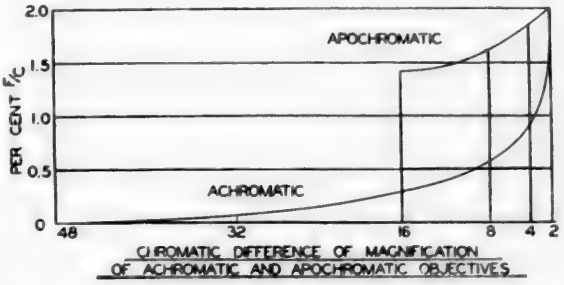

FIG. 4. ABSCISSAE REPRESENT FOCAL LENGTH IN MILLIMETERS OF MICROSCOPE OBJECTIVES. ORDINATES REPRESENT PERCENTAGE OF GREATER MAGNIFICATION FOR BLUE LIGHT THAN FOR RED LIGHT OF MICROSCOPE OBJECTIVES

given in percent ratio of the magnification of the blue image to the red image. The lower curve is for achromatic objectives and the upper curve for apochromatic objectives.

There are three types of microscope eyepieces available for visual use. These are the *Huygenian, Hyperplane* and *compensating*. A fourth class, apt to be found in micrometer eyepieces, is the *Ramsden*. The *Huygenian* eyepiece consists optically of an unachromatic eyelens, and an unachromatic collective lens. As mentioned before, this eyepiece is negative, that is, the focal plane (position of object) lies between the lenses. This makes a suitable eyepiece for examining the image formed by a microscope objective. The eyepiece is achromatic because the focal lengths of the eyelens and collective are chosen so that their sum divided by 2 equals their separation. The term achromatic, applied to an eye-

piece, means that the focal lengths for two colors is the same. This is one requirement a lens must meet to form a color free image when the lens is used as a magnifier, or when the object is either at its focal point or at infinity. Thus, *Huygenian* eyepieces will form a color free image if the object is color free. The object for a microscope eyepiece is the image formed by the microscope objective. Low power achromatic objectives give substantially color free images and thus the *Huygenian* eyepiece is quite suitable for use with such objectives.

Huygenian eyepieces as made for the microscope are not strictly achromatic but have their focal length for blue light slightly longer than for

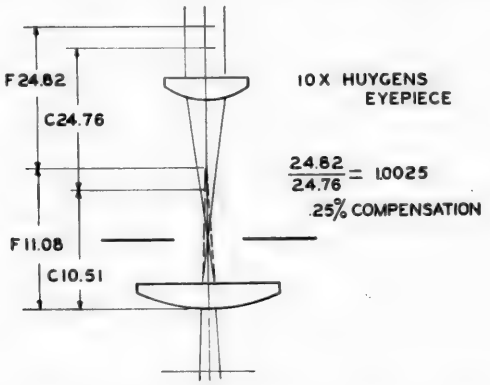

FIG. 5. DIAGRAM SHOWING THE POSITION OF THE FOCAL POINTS FOR *F* (BLUE LIGHT) AND *C* (RED LIGHT) FOR A 10× HUYGENS EYEPIECE

The focal length for blue is greater than for red. The ratio of the focal length for blue light to the focal length for red light represents compensation.

red light in order to partially compensate the undercorrection of the achromatic objectives. The average compensating power of the *Huygenian* eyepieces is 0.25 percent. As can be seen from figure 4, this compensation of the *Huygenian* eyepieces exactly neutralizes the undercorrection of the 16-mm. achromatic objective. Thus, the image as seen through these eyepieces used with a 16-mm. achromatic objective should be quite free from primary color. There will be left secondary spectrum colors. When these eyepieces are used with objectives longer in focal length than 16 mm. there will be somewhat over compensated colors at the margin of the field. Figure 6 shows the amount of residual color in percent when the *Huygenian* eyepiece is used with the achromatic objectives and fluorite objectives.

Such residual colors as we are discussing here naturally are only of consequence when the illumination is white light. If color filters are used and these color filters transmit narrow bands of the visual spectrum the residual chromatic difference of magnification does not exist. On the other hand, objects which are colored due to stain used in their preparation may give a false impression if they are at the margin of the field and examined with an optical system having considerable residual chromatic difference of magnification. This last statement applies only when white light is used as a source. Examining again figure 4, it is obvious that since the high power achromatic objectives have considerable chromatic difference of magnification, false impressions of objects in the periphery of the field may be had if *Huygenian* eyepieces are in use. The chromatic

Huygenian Eyepieces

Achromatic Objectives		
48.0 mm.	Residual Chromatic	+0.25 percent
40.0 mm.	Residual Chromatic	+0.25 percent
32.0 mm.	Residual Chromatic	+0.25 percent
16.0 mm.	Residual Chromatic	None
8.0 mm.	Residual Chromatic	−0.4 percent
4.0 mm.	Residual Chromatic	−0.7 percent
1.9 mm.	Residual Chromatic	−1.5 percent

FIG. 6. THE AVERAGE COMPENSATION FOR HUYGENIAN EYEPIECES IS 0.25 PERCENT

The subtraction of 0.25 percent from the chromatic difference of magnification values read from the curves in figure 4 gives the residual chromatic difference of magnification existing when Huygenian eyepieces are used with microscope objectives.

difference of magnification existing in such objectives can be compensated for, or partially compensated for, by making eyepieces hyperchromatic, that is, making them have longer focal lengths for blue light than for red light, and as a consequence not magnify the blue image as much as the red image and thereby recombine these colors in the final image to produce white light.

This is the main function of both the *Hyperplane* and the *compensating* eyepieces. The *Hyperplane* eyepiece in powers 5×, 7.5×, 10× and 12.5× is a negative eyepiece similar to the *Huygenian* eyepiece but has an achromatic eyelens, and the ratio of the sum of the focal lengths of the collective and eyelens to the separation between them is unlike the *Huygenian* eyepiece. The achromatic eyelens serves two functions, one to produce chromatic difference of magnification opposite to that of the microscope

objectives, and the other to introduce overcorrected curvature of field. These eyepieces are hyperchromatic and when used with high power achromatic and low power apochromatic objectives compensate some of the chromatic difference of magnification inherent in them. They should not be used with low power achromatic objectives because they will introduce color at the margin of the field and will cause poor definition in the margin of the field because of their overcorrected curvature of field. The 15× and 20× *Hyperplane* eyepieces are orthoscopic, and have the same compensating effect as the other powers. The orthoscopic eyepiece is a positive eyepiece consisting of a triplet collective and a single eyelens

The average compensating of the *Hyperplane* eyepiece is 0.8 percent. Reference to figure 4 will show that these eyepieces pretty nearly com-

Hyperplane Eyepieces

Achromatic Objectives		
8.0 mm.	Residual Chromatic	+0.15 percent
4.0 mm.	Residual Chromatic	−0.15 percent
1.9 mm.	Residual Chromatic	−0.45 percent
Fluorite Objectives		
4.0 mm.	Residual Chromatic	−0.1 percent
1.8 mm.	Residual Chromatic	−0.9 percent

FIG. 7. THE AVERAGE COMPENSATION FOR HYPERPLANE EYEPIECES IS 0.8 PERCENT

The subtraction of 0.8 percent from the chromatic difference of magnification values read from the curves in figure 4 gives the residual chromatic difference of magnification existing when Hyperplane eyepieces are used with microscope objectives.

pensate the chromatic difference of magnification of the high power dry achromatic objectives. The residual chromatic difference of magnification existing when the *Hyperplane* eyepieces are used with the high power achromatic objectives including the oil immersion and with the fluorite objective is given in figure 7. The appearance of the image when the *Hyperplane* eyepieces are used with these objectives will be much better with respect to primary colors than if the *Huygenian* eyepieces are used.

The *compensating* eyepieces go one step farther in compensating chromatic difference of magnification. The average compensating power of these eyepieces is 1.5 per cent. In figure 4 it will be noticed that the chromatic difference of magnification of the apochromatic objectives

varies from 1.4 to 2.0 per cent. If the compensating eyepieces are used with the apochromatic objectives the residual color at the margin of the field will be rather small. Furthermore, it will be noticed that the achromatic and fluorite oil immersion objectives have substantially the same quantity of chromatic difference of magnification as the apochromatic oil immersion objectives. Therefore, they, too, will be well compensated with the compensating eyepieces. The kind of color remaining at the margin of the field when compensating eyepieces are used is secondary color and not primary color. Compensating eyepieces in the powers 5×, 7.5×, and 10× are of the negative type similar to the *Hyperplane*, while the 12.5×, 15×, and 25× are orthoscopic. Figure 8 shows the

Compensating Eyepieces

Achromatic Objectives			
1.9 mm.	1.25	Residual Chromatic	−0.3 percent
Fluorite Objectives			
1.8 mm.	1.30	Residual Chromatic	−0.2 percent
Apochromatic Objectives			
16.0 mm.	0.25	Residual Chromatic	+0.1 percent
8.0 mm.	0.65	Residual Chromatic	−0.1 percent
4.0 mm.	0.95	Residual Chromatic	None
2.0 mm.	1.30	Residual Chromatic	−0.5 percent

FIG. 8. THE AVERAGE COMPENSATION FOR COMPENSATING EYEPIECES IS 1.5 PERCENT

The subtraction of 1.5 percent from the chromatic difference of magnification values read from the curves in figure 4 gives the residual chromatic difference of magnification existing when Compensating eyepieces are used with microscope objectives.

percent of residual chromatic difference of magnification left when these eyepieces are used with the apochromatic objectives, and with the achromatic and fluorite oil immersion objectives.

The fourth type of eyepiece, which we have not discussed before, is the *Ramsden*. This eyepiece when truly a *Ramsden* eyepiece is perfectly achromatic, and, when used with any of the microscope objectives except the lowest power, will show decided undercorrected chromatic difference of magnification. A truly *Ramsden* eyepiece is one in which the eyelens and collective lens may be used or implied. Both have the same focal length and the collective lens lies in the principal focus of the eyelens. This means that any marks, whether they be accidental, such as dirt or scratches, or intentional marks such as

a scale on the collective, will be in sharp focus. As a consequence very few *Ramsden* eyepieces are in existence. Usually the *Ramsden* eyepiece is modified so that the focal point of the eyelens falls beyond the plano surface of the collective, and any marks on the latter will not be seen in the field. Making the eyepiece in this manner gives it under correction or adds to the lack of its compensating power. All attempts made to compensate this kind of eyepiece fail completely, because there exists no optical glass having suitable optical characteristics for its correction. The *Kellner* eyepiece is a modified *Ramsden* and falls in this class. Such eyepieces are sometimes called wide field eyepieces, and serve admirably when used with low power objectives, but fail with

48.0 mm.	Achromatic Objective	Huygenian Eyepiece	+0.25 percent
40.0 mm.	Achromatic Objective	Huygenian Eyepiece	+0.25 percent
32.0 mm.	Achromatic Objective	Huygenian Eyepiece	+0.25 percent
16.0 mm.	Achromatic Objective	Huygenian Eyepiece	None
8.0 mm.	Achromatic Objective	Hyperplane Eyepiece	+0.15 percent
4.0 mm.	Achromatic Objective	Hyperplane Eyepiece	−0.15 percent
1.9 mm.*	Achromatic Objective	Compensating Eyepiece	−0.3 percent
4.0 mm.	Fluorite Objective	Hyperplane Eyepiece	−0.1 percent
1.8 mm.*	Fluorite Objective	Compensating Eyepiece	−0.2 percent
16.0 mm.	Apochromatic Objective	Compensating Eyepiece	+0.1 percent
8.0 mm.	Apochromatic Objective	Compensating Eyepiece	−0.1 percent
4.0 mm.	Apochromatic Objective	Compensating Eyepiece	None
2.0 mm.*	Apochromatic Objective	Compensating Eyepiece	−0.5 percent

* Oil immersion objectives.

FIG. 9. It is possible to so choose an eyepiece to use with a particular microscope objective so that the residual chromatic difference of magnification does not exceed 0.5 per cent. In most instances this residual chromatic difference of magnification may be reduced to much smaller values.

respect to color correction completely when used with high power objectives.

It should be noticed in figures 6, 7 and 8 that in the majority of objectives and eyepiece combinations there is some residual color left at the margin of the field. In no case does this quantity need to exceed 0.5 percent if the proper eyepiece has been selected for the objective being used. Figure 9 collects the data already presented but gives only the best eyepiece for each objective, and the residual chromatic difference of magnification for the combination. If combinations of objective and eyepiece as given in this table are used, the detail in the object will be most faithfully reproduced in the visual image.

A NEW CAMERA BOX FOR THE PHOTOGRAPHY OF GROSS PATHOLOGICAL SPECIMENS[1]

FRANCIS A. OPPS

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The difficulty of obtaining gross photographs of pathological specimens free from high lights, and without loss of detail, has prompted the development of a new box with the object of eliminating these disadvantages. It is well known that specimens photographed with flood lights reveal highlights varied in number and extent, and leading to partial loss of the details of the photographic image figure 1A. Even the photography of specimens immersed under water is not without its disadvantages. Thus, the bloody discoloration of the water by the fresh specimen, and the filling in of any superficial crevices and depressions by water, cause respectively, loss of detail as high as 20 to 30 per cent of the total photographic image, and the artificial flattening of the tissue crevices and the depressions as illustrated in figure 1B.

By the diffusion of light from ten frosted 100 watt Mazda lamps through frosted glass, a soft, constant and uniform light plays on the specimen from two sides of the box, shown in figure 2. Such a light eliminates highlights, and permits the photographer to determine the desired exposure with greater ease. In our hands, an Eastman 5 x 7 clinical camera with a Bausch and Lomb Tessar I c. f.: 4.5 lens mounted above the box, yielded the best results, although any other similar camera can be substituted. The bench shown in figure 2 can accomodate large specimens, and can be removed readily from the box for specimens of extreme size.

The construction of the box is comparatively simple, and can be carried out at a nominal cost by any skilled carpenter, after a carefuly study of the diagrams shown in figures 3, 4 and 5.

It is essential to prevent the oozing of fresh blood by coagulation, and loss of color by fixation of the specimen in Jores fluid no. 1, for from one to twenty-four hours, depending upon its size. Fixation in this fluid must not be prolonged over twenty-four hours because of the blending of colors, and the consequent distortion of the gray tones of the photographic image. Should the colors of the specimen be altered by excessive fixation in

[1] Received for publication November 9, 1933.

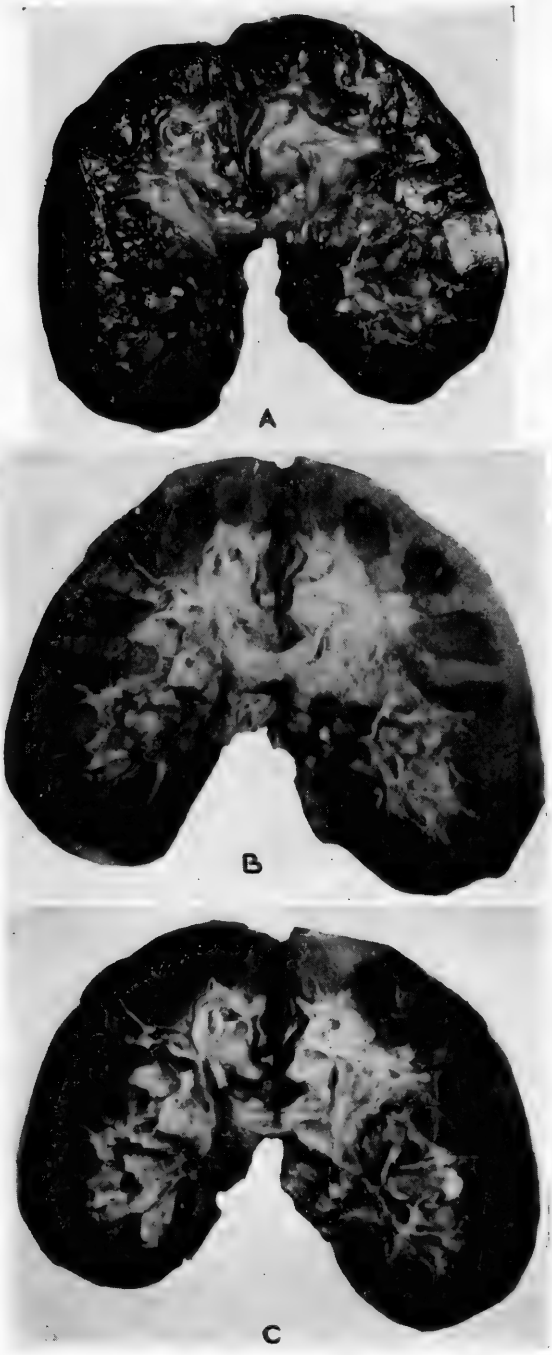


FIG. 1

A. Photograph of a fresh, unfixed kidney with flood lights. Note highlights with loss of detail.

B. Photograph of same kidney as *A* in fresh unfixed state taken under water. Note flattening and filling in of purposely produced ridges clearly reproduced in *C*. Also note loss of detail as compared with *C*.

C. Photograph of same kidney as of *A* and *B* in fixed state with camera box. Note absence of highlights, reproduction of ridges, retention of detail, and sharper contrast of cortex and medulla in comparison with *A* and *B*.

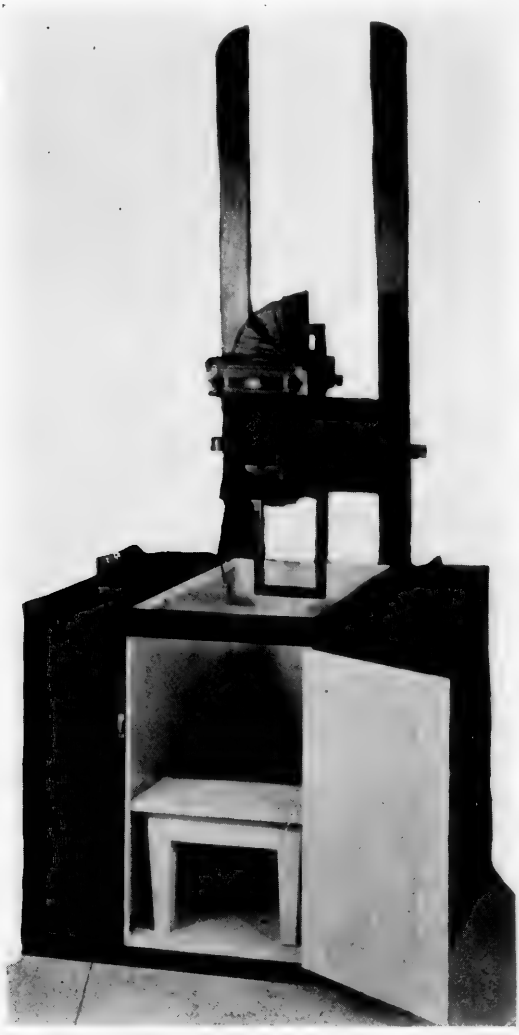


FIG. 2. CAMERA BOX

Jores fluid no. 1, they may be quickly and materially restored by immersion in 70 per cent alcohol for a few minutes. Human brains fixed in 10 per cent U.S.P. formalin photograph excellently.

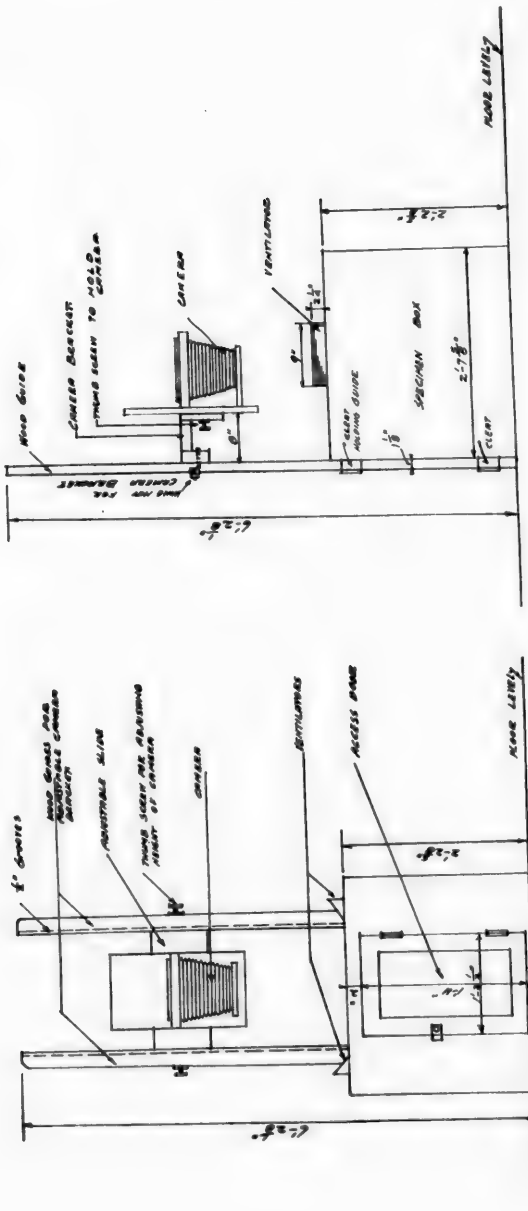
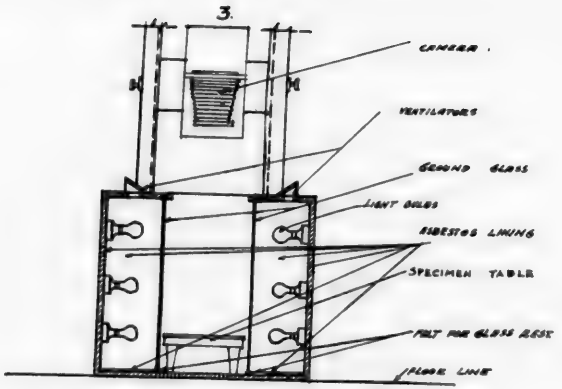
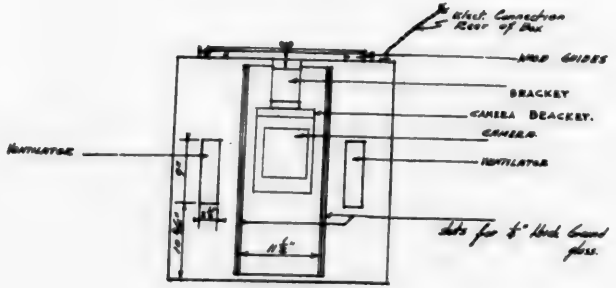


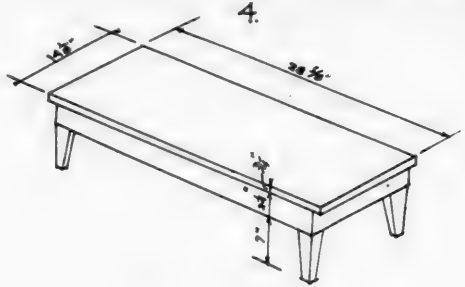
FIG. 3



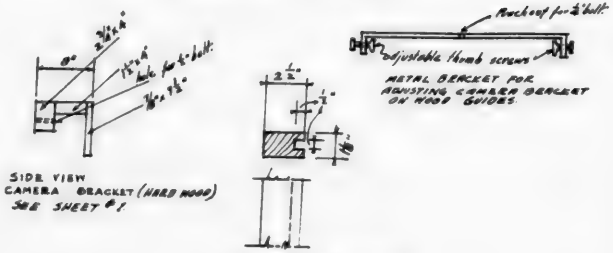
FRONT INTERIOR WITH DOOR AND FRONT COVERING REMOVED



TOP VIEW



SPECIMEN STOOL



SIDE VIEW CAMERA BRACKET (HARD WOOD) SEE SHEET #1

WOOD GUIDE (Hardwood) SEE SHEET #2

SECTION THRU VENTILATOR SEE SHEETS #1+2.

ELEVATION TOWARD OPENING SEE SHEET #1+2

FIG. 4

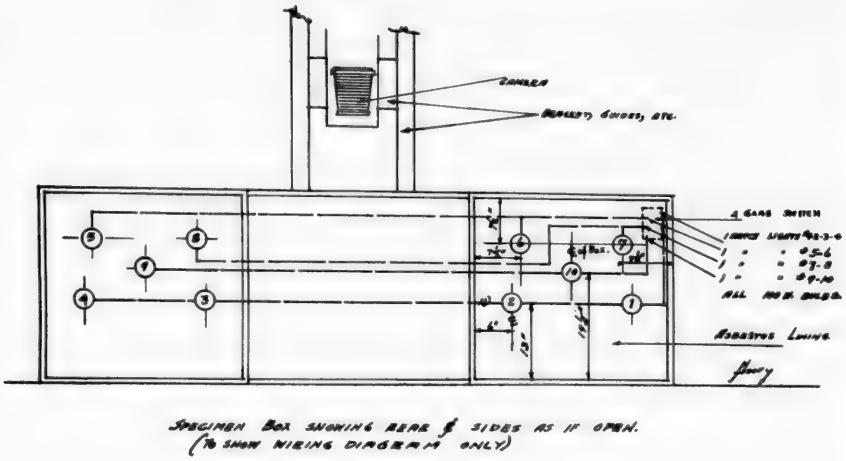


FIG. 5

FIG. 6. ROUTINE PHOTOGRAPH WITH CAMERA BOX OF A FIXED PRIMARY MESOTHELIOMA OF THE LUNG

THE MINIATURE CAMERA IN SCIENTIFIC PHOTOGRAPHY[1]

KARL A. BARLEBEN, JR.

E. Leitz, Inc.

Until a comparatively few years ago, small cameras have been ignored for serious purposes. Indeed, even to-day, a great many photographers scoff at them. Happily, the tide is turning, and people are gradually becoming aware of the marvelous advances which are being made right along in this newest of photographic fields. The small camera is no longer a novelty, a toy, but a real, serviceable instrument, capable of duplicating anything possible with the more conventional larger equipment. The increasing popularity of the miniature camera is not alone due to its small size and compactness, but to its greater versatility and *economy* as well. These advantages over larger equipment cannot be overlooked for long, and it is reasonable to suppose that if it is definitely proven that small cameras can turn out results which equal those produced with larger equipment, prejudice can soon be overcome. That is exactly what is happening to-day—photographers in every field are slowly learning of the amazing results produced by the miniature camera.

There are many different types and makes of small cameras, and we must not make the mistake of classifying them all in one group. By far the vast majority are of limited scope, suitable mainly for snapshot work and general photography. For the more specialized fields, a camera capable of coping with the various conditions encountered must be used, a camera which permits a variety of accessories and attachments to be fitted to it *interchangeably*. At this writing there are but two such instruments. The one permitting the greatest range is the well-known Leica camera, the pioneer in precision small cameras. This camera was introduced to the world approximately ten years ago, and since that time has maintained the lead right down to the present.

Despite the fact that new models appeared from time to time, it is interesting to note that basically the design and construction remained the same throughout the years—a tribute to the mechanical genius of Mr. Barnack, the designer of the camera.

To-day, the Leica is represented by three separate and distinct models—distinct models, yet basically the same. There is the Model E, which might be termed a "stripped" camera, because it does not

[1] Received for publication July 5, 1933.

incorporate a few of the refinements found on the other models. Nevertheless this model serves its purpose splendidly in cases where these refinements are not required and desired, such as in copy and micro-photography. The Model D might be considered the "standard" model for all general purposes. It is equipped with the built-in automatic focusing device which has won for it the nick-name "Autofocal." Lastly is the recently introduced Model F, equipped with almost every refinement and convenience anyone could possibly desire. Of special importance in this model is the slow shutter speed range, by means of which, accurate exposures as slow as a full second can be made. All Leica camera models are instruments of precision, mechanically and optically, and as such appeal strongly to the scientist, who appreciates such precision. It is due to this precision, too, that the versatility of the camera is made possible.

It is not the purpose of this article to dwell on the working methods involved when using the Leica camera in scientific fields, but rather to indicate to the reader a few of the more outstanding possibilities of it. The Leica is too well-known to merit a detailed description, however, it may be well to point out that the camera measures approximately $5\frac{1}{4}$ x $2\frac{1}{2}$ x $1\frac{1}{4}$ inches overall and weighs only 19 ounces complete. It accommodates 35 mm. standard cinema film, producing negative images 1 x $1\frac{1}{2}$ inches in size. Thirty-six exposures can be made at a loading. It is equipped with a highly efficient focal plane shutter which gives exposure speeds from one full second up to one-five-hundredth of a second.

For casual photography it is ideal, due to its size, and quickness in operation. Many dentists and physicians use it exclusively, for photographing patients and special subjects of which they want to have a record for future reference. Because the camera can be carried in the pocket when not in use, and can be brought into action in a matter of a few seconds, pictures of hospital activities can be recorded instantly—and without interfering with anyone or anything. The automatic focusing feature eliminates guess-work, hence sharp, clean-cut pictures are assured.

Photographs of dental and surgical operations can be made most easily. Formerly the large 5 x 7 or 8 x 10 camera, depending upon a tripod for support, was used for such record-photographs. Before the first exposure could be made, considerable preparations were neces-

FIG. 1

sary. The tripod had to be set up and adjusted, the camera fastened to the tripod, the lights arranged. Still pictures could not be made until after the camera had been focused, the plate-holder inserted in its place, the dark-slide drawn, and final adjustments made. All this required not seconds, but minutes. In the meantime both patient and surgeon were apt to become uncomfortable and fidgety. Indeed in some emergency cases such a procedure was practically impossible.

The story is quite different to-day. No special lights are needed because of the ultra-speed lenses and films now available. No tripod is necessary because instantaneous exposures are ordinarily possible with-

FIG. 2

out elaborate illumination. There is no time lost in focusing the camera —this is done automatically in an *instant* by means of the built-in focusing device. There is no space taken up by the camera on the awkward tripod. The whole procedure is done in a few seconds. What is more, at least ten to fifteen different exposures can be made during the operation in the same time which was formerly required to make but one.

In fact there is a special device now available embodying a metal frame-work which is carried by the photographer. Upon this frame-work are mounted two special incandescent lamps in reflectors, the

camera, and a special view-finder. Armed with this equipment, the photographer, or anyone handy for that matter, can work his way in and around the scene of activity, snapping scenes of all important points, from desirable angles *without interfering with the operation in the least or getting in the way of the operators.* Surely such revolutionary advances in scientific photography cannot be ignored for long. Many hospitals and institutions having need for photographs are already using such equipment in their routine work, and the day is not far off when photographic activities of this nature will very likely be taken with the small camera.

Another point not to be lightly cast aside is the economic factor. Films for the small camera are inexpensive. Each negative costs on an average of not more than a penny. Compare this with the cost of the regular larger negative! The results with the small camera are comparable in many ways with those produced by the larger equipment. In short, then, there is little lost by using small equipment. On the contrary, there is often much to be gained.

On considering a few of the specialized fields, such as photomicrography, copying gross objects, and radiographs for record purposes, we again find the Leica offering its unusual advantages and economies.

In photomicrography, special apparatus is usually required if the results are expected to be at all useful. Such equipment is costly, bulky, and demands skilled technicians to operate it. On the other hand, the Leica camera may be fitted with a simple attachment, which immediately converts it into a full-fledged micro camera. No special braces, no platform, no other extra equipment of any sort is required. This attachment is known as the Micro-Ibso attachment, and consists of a cone, one end of which terminates in a collar which encircles the ocular or eyepiece. The other end of the cone screws into the camera lens-flange in place of the lens. A Compur shutter and right-angle focusing "beam-splitter" are built into the cone. The entire unit merely fits into the top of the microscope draw-tube. Its weight is negligible, hence no fear need be felt of its toppling over, or sagging the extended draw-tube of the microscope. The focusing "beam-splitter" permits the specimen to be delicately focused. When ready for the exposure, a cable-release is pressed, which removes the prism, permitting the full illumination to reach the film in the camera. This arrangement is ideal when photographing living specimens, for the focus and movement of the object can

be adjusted constantly, and when a favorable opportunity arrives, the exposure can be made instantly by depressing the cable-releases (two) simultaneously, one for the prism, and the other for the actual exposure as produced by the Compur shutter.

FIG. 3

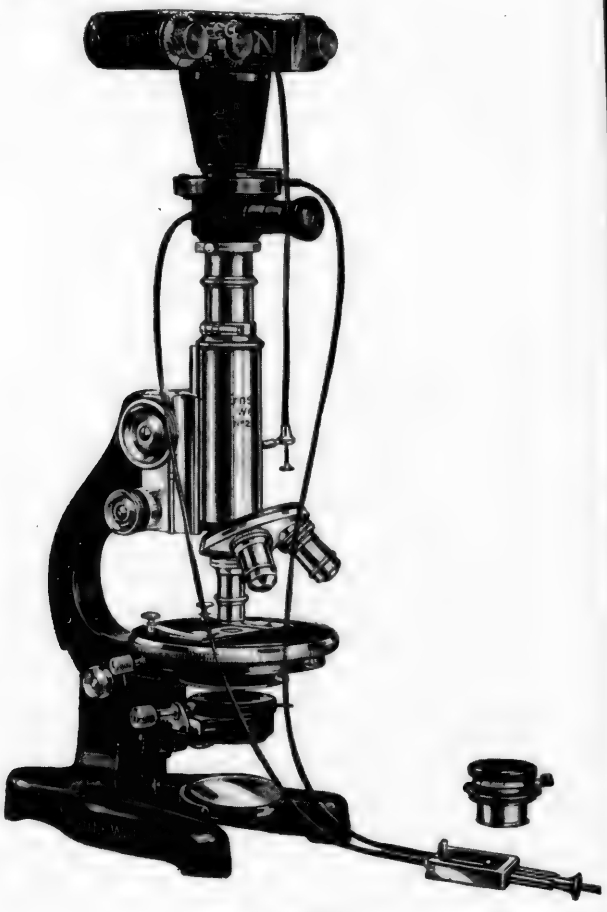


FIG. 3A

For hasty or occasional photomicrographs, a small adapter ring is also offered, which simply clamps the camera lens to the eyepiece of the microscope. In this case the camera lens is used, of course. The lens is naturally set at the infinity focus when used in this manner.

In making photographs with the small cameras, some attention must

be paid to the type of film best suited for the work. In the majority of cases, the micro specimens are stained, which indicates a film sensitive to the various colors, in other words, panchromatic film. Secondly, a fine-grained film should be used if the photomicrographs are to be enlarged—which they usually are. A combination of both fine-grain and color sensitivity is a difficult combination to find, however, DuPont quarter-speed panchromatic film seems to be the answer. It has fine-grain, color sensitiveness, and just the proper degree of contrast, making it the ideal material for this purpose. Practically all workers in this field agree that this film is the best suited material, hence can be

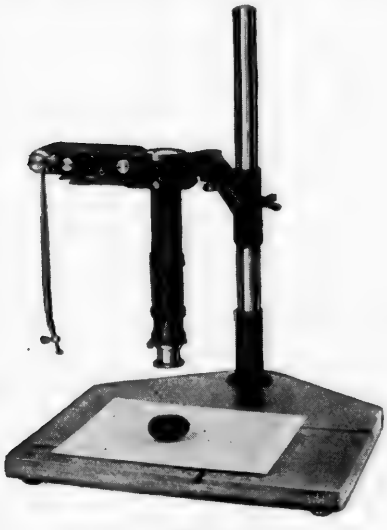


FIG. 4

FIG. 5

highly recommended without question. Regular orthochromatic and panchromatic films can of course be used, too, but experience indicates that the best results are possible with the DuPont quarter-speed film.

For copying gross objects and sections, small plants, rocks, minerals, stamps, maps, manuscripts, documents, records, and the like, the small camera again offers its services in a most admirable manner. There are various devices available which lend themselves to the copying of objects of this nature. The Leica Camera has the Sliding Focusing Copy Attachment which permits ground-glass focusing and various degrees of low magnification directly in the camera without the aid of a microscope.

This is a most universal device, for it may be used for practically any type of object, at any near distance, and to cover any small area. For those who are interested primarily in definite objects which do not exceed a set size or area, special Reproduction devices are to be had. These make use of extension "legs" which indicate the boundaries covered by the lens. Some of these devices focus the lens by means of special supplementary front lenses, while others provide for the use of intermediate extension tubes which separate the lens and the camera, thereby securing the proper focus. Dentists, for example, use this type of equipment a good deal because it permits them to photograph only a patient's mouth or a certain area thereof. This equipment may be used vertically or horizontally, and in the case of the former, the "legs" serve as a support for the camera besides indicating the area covered.

In photography of this nature, the selection of film depends upon the nature of the object and its color. Dentists, working on mouths would ordinarily select panchromatic film in order not to render the interior of the mouth too dark or black. The same holds true of surgeons photographing gross specimens—the panchromatic film is able to preserve in most cases the true color-relation of blood, flesh, skin, tissue, etc. When photographing black and white objects such as printed pages, manuscripts, diagrams, etc., where a strong contrast is required, positive film is indicated. This holds true only when the object being photographed is black and white. Should there be coloring in it, such as is the case of colored maps, a panchromatic film should be used. Ordinarily contrast is a desirable factor, and again we recommend the DuPont quarter-speed panchromatic film. Where delicate shadings appear in a black and white object, such as a photograph, regular orthochromatic film is best. Common sense and a little experience will ordinarily be useful in making the best selections.

Radiographs are often copied in smaller size for future reference on slides or paper prints. The method of making such copies is quite simple with the small camera and a light-box, equipped with several frosted or opal mazda bulbs which are covered with a sheet of ground glass. The X-ray negative is laid on the ground-glass, and the camera secured above at the proper height to include the entire field by means of the sliding focusing copy attachment. When the bulbs are lit the exposure is ready to be made. Apparatus for this work is likewise available for use with the Leica camera.

In copying radiographs, an orthochromatic film is in all cases indicated, although panchromatic film may be used if desired, although there is no reason for using panchromatic film for this purpose. Films possessing the necessary fine-grain include Eastman Panatomic, Agfa Plenachrome, Perutz Persenso, Gevaert Express Superchrome, Mimosa Extrema, and

FIG. 6

Selochrome. Note that positive film, or any other film possessing considerable contrast is not to be used, as delicate shading is very apt to be lost, thus resulting in a copy which is practically void of detail. The shadings and details are of great importance if an accurate diagnosis is to be made, hence they must, at all cost, be preserved in the copy.

From this brief review it will be seen that the small camera offers many extraordinary advantages to the scientific worker. Small size, compactness, ease of operation, precision in design and workmanship, versatility, and economy are all factors, any one of which would justify its use. A battery of eleven different lenses, varying in speed and focal length add to the utility of the Leica. The speed lenses are of particular importance, for with them, photographs can be successfully produced under adverse lighting conditions. Developing equipment is small and efficient, using only about sixteen ounces of solution to develop the entire roll of 36 pictures. Enlarging apparatus of special optical design is available which secures the utmost from the negatives, and produces pictures two by three feet in size if necessary. Projection equipment permits the use of film-slides and glass slides made direct from the miniature camera negatives. This equipment will be found invaluable for teaching purposes where large classes or groups can be assembled.

The value of photography in scientific fields is well-known. Progress has devised ways and means of reducing size, bulk, and cost in recent years, factors which are of vital importance to all concerned. The small camera offers the photographer a new conception of photography, a more complete range of versatility, a new economy.

RELATION OF LABORATORY EXAMINATION TO THE PHOTOGRAPHY OF BIOLOGICAL MATERIAL*

LOUIS SCHMIDT

From the Illustration Division of The Rockefeller Institute for Medical Research

Sometimes the photographer is asked to make a picture of a growth, in a test tube or on a petri dish, so obscure as to be invisible, except with very special lighting conditions. In some cases, there may be liquid, or liquids, in tubes showing a line of flocculation, or a line where the liquids meet.

Such subjects are difficult to handle, and it is important to observe how the scientist places them, in relation to light and background, when he studies them. This is necessary because the photographer must as nearly

* Received for publication September 1, 1933.

as possible reproduce those conditions in relation to the camera, as the specimen is demonstrated to his eye.

A rack full of test tubes, showing various degrees of translucence, or varying degrees of precipitation, would very naturally be placed on a window sill, or in front of a sheet of white cardboard brilliantly lighted, without any strong light on the tubes. Sometimes the differentiation in degrees of density is greatly improved by placing a wire or thread horizontally behind the tubes, thus showing not only the degree to which the light background is obscured by the varying lack of transparency of the preparation but also the greater or lesser clearness of the wire or thread.

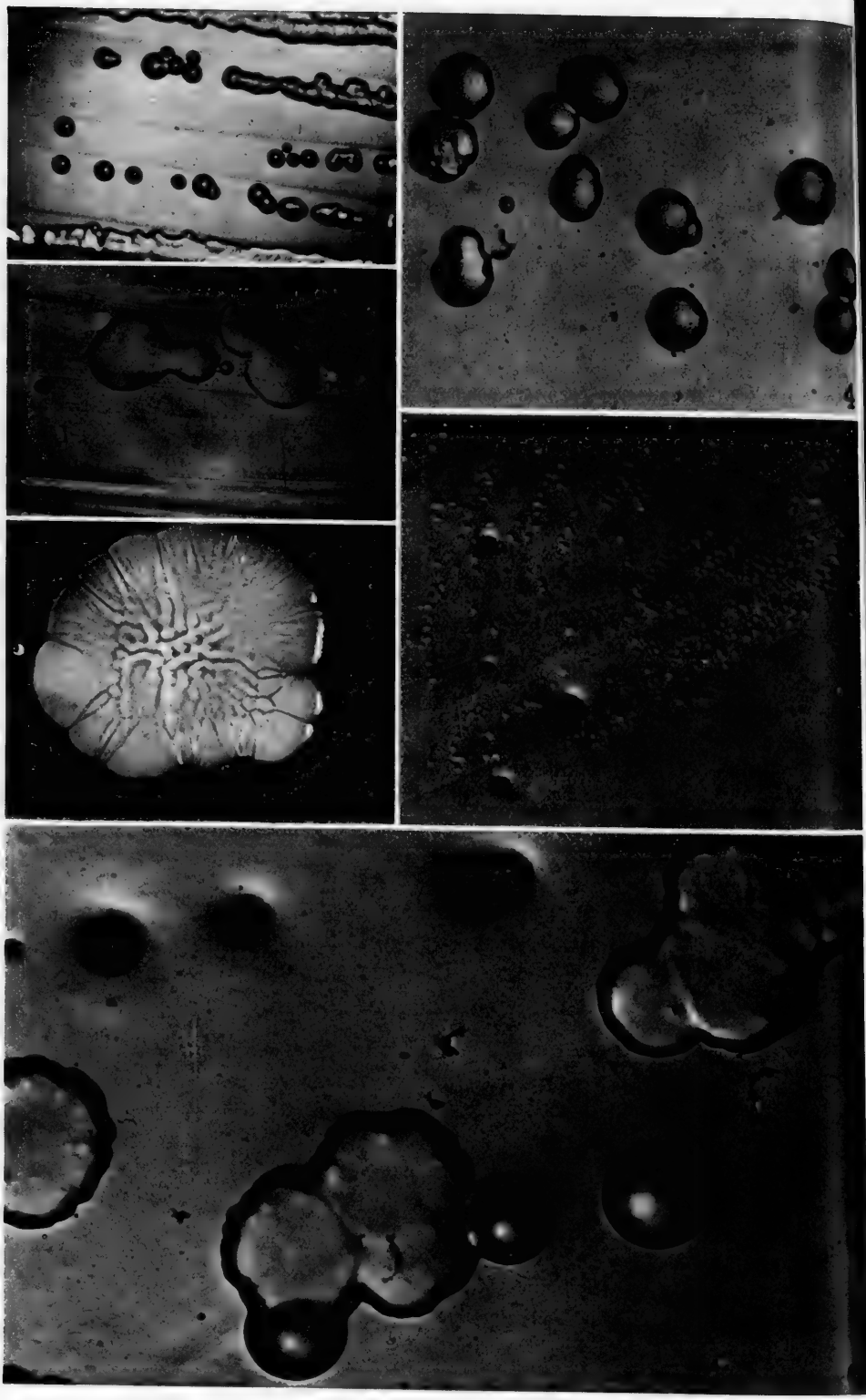
In the case of the suspension of transparent particles in clear liquid, or almost colorless precipitate, the matter of light, background and placement of camera is very important. I place the tube or rack of tubes upright on a window sill. Six inches behind the preparations is placed a

FIG. A

piece of black cardboard. The camera level is the same as that of the tubes making the lens about the height of the preparation. The daylight falls on the preparations from above and behind flooding them with light, excentuating solid particles clearly against the black background, producing a similarity to a microscopic darkfield. Tissue cultures in flasks are handled in the same way for low magnifications.

When daylight is not available, I have used a Cooper-Hewitt tube placed horizontally, slightly behind and above the black background with satisfactory results. Little or no light should fall on the front of the preparation. Sometimes the contrast is increased by moving the specimen closer or farther from the background. A contrasty plate is preferable.

Rough and smooth colonies, magnified up to fifteen diameters are in demand. The best method to show them is a very live problem. Again



Courtesy Journal of Experimental Medicine

FIG. 1

I recommend that the photographer take into account how such cultures are studied and demonstrated in the laboratory. Often they are placed on a microscope having a stage which is mounted on a metal hemisphere, resting in a suitable socket, so that it may be tilted in all directions, as well as rotated. The petri dish culture is placed on this, and lighted with an ordinary frosted bulb which is inverted and placed the height of the ocular. The stage is manipulated until the culture material appears as silver. The colonies are then shown in sharp relief with strong highlights and shadows. Owing to the angle of the specimen to the lens, only a narrow strip will be in focus but as reflected light is used the lens may be stopped down, causing the band of sharp focus to become broader. If a swing back camera were used that device also might help in bringing a wider band into sharp focus. However, I have not used such a camera.

For this work I have used lenses from 20 mm. to 100 mm. in focal length. Of course, with a weak light source and a small diaphragm opening, the exposure must be fairly long. For lighting, I use a goose neck pedestal stand with incandescent bulb, and sometimes place a piece of ground glass between the light and the specimen. As such lighting effects are rather hard, the plate must not be too contrasty.

PHOTOGRAPHIC TECHNIC, NEW PROCESSES AND EQUIPMENT

F. R. HARDING

From the Photographic Department, Children's Hospital, Boston, Massachusetts

LIGHTS, LIGHTING AND BACKGROUND

The choice of proper lights, and the placing of these lights, form two basic elements of good clinical photography. The following comment is founded upon long experience with various sources of illumination. The comment applies only to their employment in clinical photography.

Daylight does not make a good light source, for it varies in intensity with each hour of the day, making correct exposure of the negative difficult. Artificial lights are of several types, some of which are not suitable for clinical photography. Arc lights are sometimes employed, but they are bulky, are not readily portable, and require almost constant attention, unless equipped with an automatic feed for the carbons. Their employment is not recommended, except for photomicrography. The mercury vapor tube should not be employed. The light from this tube is largely from the violet end of

the spectrum. Photographs taken employing mercury vapor for illumination, show exaggerated color values. Photo flash bulbs are too costly for other than occasional employment. Generally speaking, any flash type of illumination is unsuited for clinical work. The placement of shadows is often of great importance, and with flash illumination, one cannot tell just where the shadows fall. Photo flood bulbs are good if there is only a small amount of clinical photography to be done. They are not as powerful as some other types of artificial light. The life of such lamps is short.

An ideal source of light is the 1000 watt lamp. This is made in several styles, and can be obtained with either a clear or photo blue shell. The types most commonly used are the tubular (G. E.–T20C—1000W.), and the pear shaped (G.E.–PS52C–1000W.). These lamps should be placed in reflectors. The tubular lamp employs a smaller reflector, and takes up less room, but it has a somewhat shorter effective life than the pear shaped lamp. The tubular lamp is burned glass end up, and the pear shaped lamp is burned with the glass end either up or down. When purchasing a reflector for these lamps, be sure that it will spread the light evenly. Some reflectors produce a more intense spot of light in the center of the field of illumination, others project intensely bright lines of light throughout the field of illumination. Portability is one advantage found in employing 1000 watt lamps as two of these lamps may be transported quite easily.

A description of the lighting equipment, background and accessories, at the Children's Hospital, Boston, might be of interest, for they are being employed very successfully. The lighting equipment consists of five 1000 watt lamps, clear tubular type in Fotolite reflectors, and a photo flash bulb outfit which is used only for publicity photographs. For most clinical and pathological work, two of these lamps are employed. Two to five lamps are used in making motion pictures. Special electric outlets are provided, each on a separate circuit, and separately fused for the proper amperage. Any ordinary electric circuit will take one 1000 watt lamp, but if more than one is to be used on the same circuit, the institution's electrician should be consulted before installation.

For "flat" lighting of a patient, one lamp is placed at each side of, and about four feet from the patient. The lights are "raw," not diffused. Rapid exposures are necessary in working with children. Lateral lighting was discussed at length in this department in the December 1933 issue. These two kinds of lighting and their variations cover every clinical need.

The background at the above mentioned hospital extends from the floor to the ceiling, and is eight feet in width. It is painted flat black containing no trace of gloss nor will the pigment come off when it is rubbed. The paint was applied directly to the wall. In conjunction with the background, an examining table twenty-six inches high is employed. The patient stands, sits or lies on the table, as directed. This table is normally pushed back against the background. It is covered with a dark red rubber sheet, which is allowed to hang down about a foot in front. The rubber sheet is easily kept clean, and being dark red, photographs black. The sheet should have as little gloss as possible.

Association News

News of the *Association's* activities is of vital import to every member and it is our intention to publish in this section, items that are of interest to all. The success of *Association News* is dependent largely upon the members. News of members, as to the work they are doing—the papers they are writing—the exhibits they make—not news *à la Winchell*, but enough to show that members are up and doing. Write the facts to us and we will do the rest. Photographs of members and their activities are welcome. Convention news and photographic exhibition information of interest to the biological photographer, will be published.

Address all items regarding Association News to Mr. Arthur W. Fuchs, 343 State Street, Rochester, N. Y.

The response to the following letter mailed by President Ralph P. Creer to biological photographers in the vicinity of Chicago has been most gratifying and the results of the organization meeting to be held soon should be productive of much interest.

"The Biological Photographic Association was organized at the Yale Medical School more than three years ago for the purpose of bringing together men and women interested in, or directly engaged in, biological photography, for the exchange of ideas and information. Starting with the charter membership of twenty-eight, representing eight states, we have since increased that number to more than 150 representing thirty states, Canada, Mexico and other foreign countries.

We now plan to organize a Chicago chapter so that we may get together more often and discuss the various tricks of the trade or ways and means of improving our work. It would be impossible to go into the details of the organization in this letter. If you are at all interested please sign the enclosed card and return it at your earliest convenience. If there are enough people in Chicago interested, we plan to hold a formation meeting somewhere in the Loop within the next month and talk over plans of procedure. We shall also tell you more about the function of the Biological Photographic Association at this meeting.

I am sure that you will benefit greatly by such an organization, and remember that whether or not we can carry out our plans will depend upon the interest shown."

Members in other cities should make an effort to organize other local societies so that information and an exchange of ideas regarding biological photography may take place frequently.

The increasing interest in clinical photography with infra-red plates should compel us to read all available literature on the subject. A general article descriptive of some

results obtained in landscape photography may be found in the November, 1933, number of *The Camera*—written by L. A. Waters. The newly revised 11th edition of *The Photography of Colored Objects* published by the Eastman Kodak Company contains some excellent data concerning the use of infra-red sensitive materials and filters. You can obtain a copy at any photographic supply store for fifty cents. A somewhat technical article on the characteristics of infra-red rays may be found in an article *Permeability of the body to infra-red rays: a preliminary communication* by C. B. Heald, British Med. Journal, 2:54, July 8, 1933. If there is anyone who has been photographing the human breast employing infra-red plates for the detection of malignant or benign growths, we would like to know what results they are obtaining. There is reason to believe that such photographs would have decided diagnostic value.

At the last business meeting of the Society, a committee composed of Messrs. A. TerLouw, Chairman, Louis Schmidt and James Haulenbeek, was created to arrange a competitive print exhibit to be held at the 1934 Annual Convention. The success of such a venture depends largely upon the response of the members. Any attempt to conduct a competition with only a few entries would be futile; therefore, it behooves all members to get busy and enter prints as soon as possible. The committee has very generously taken it upon themselves to mount all prints. This procedure will not only make it easier for the exhibitor but will permit more uniform arrangement of photographic grouping. The committee can not at this time say just how the material will be divided for judging. That depends to a great extent upon the response. All that is asked of the members, now, is that they send prints of subjects which, while not out of the ordinary, are good examples of their work. An excellent plan in assembling a group of prints is to make extra prints of certain of your routine cases and put them in an envelope marked "B. P. A. Exhibit." Then shortly before the next convention, send the whole group to the Chairman at 343 State St., Rochester, N. Y. The purpose of the competition is not to award a prize but to obtain a demonstration of the type of work the membership as a whole is doing. It will also serve as an incentive toward improving the general average of photographic quality produced by the members. Begin now to lay aside prints. Make that extra print while you are still on the job. Do not hesitate because you feel that your contribution will not be of value. Every member should have something exhibited at the next meeting. Just attach a note to each print giving such data as the pathology and complete exposure factors—aperture—film, etc.,—also, details as to the method employed in making the picture. Photomicrographs, gross specimens, copies of radiographs, line and clinical work, anything of medical or scientific interest is acceptable. Remember that glossy, 4 x 5, 5 x 7 or 8 x 10 prints only, will be accepted.

A. W. FUCHS.

Book Reviews and Abstracts

All books or articles to be reviewed must be sent to Mr. C. B. Neblette, care of Eastman Kodak Co., Rochester, N. Y.

Photographisches Praktikum fur Mediziner und Naturwissenschaftler. Edited by Doctor Alfred Hay. Wein, Julius Springer, 1930. 30 Marks.

This book is an example of the kind of works for which the German people seem to be particularly adapted. So far as this reviewer is aware, it is the only work on photography as applied to medicine and the natural sciences which makes any pretension at adequately covering the whole field. This it may be said to do with that thoroughness characteristic of German technical works of this type. Its fifteen chapters, each by a well known authority, cover such subjects as photography in anatomy, photography in anthropology, photography in histology, photomicrography, ciné-photomicrography, photography in dermatology, radiography, electrocardiography, medical jurisprudence, legal rights in medical photography, photography in the treatment of the eye, medical cinematography and photography as applied to the study of nervous disorders. There are two chapters at the beginning which deal with the optics of photography and with photographic processes. A book of 530 pages well illustrated and with copious references and a good index, it should be of value to those familiar with the language.

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VOLUME II *June, 1934* NUMBER 4

The Journal of the Biological Photographic Association

EDITORIAL

A Plea for Experience

For many years, the standard of biological photography was very low. For proof of this statement it is only necessary to refer to any textbook or journal published more than ten years ago. In recent years the standard has improved, but there is still room for further progress.

Biological photography requires broad photographic knowledge, and experience and thorough training in all branches of commercial photography, plus a natural aptitude for biological work. It is a specialized branch of photographic art, requiring the highest type of skill. The amateur, or poorly trained professional photographer, sometimes found in institutions, lacks the general knowledge and experience of the well trained individual in processing room technique, general operating, lighting, and camera manipulation.

The training received as a portrait photographer is of little value to the biological photographer, because the former is primarily concerned with flattering his subject while the latter aims at producing a true representation. Types of lighting employed in portraiture are of less value in biological work, and the processing room technique produces negatives and prints of soft quality which are not suitable for scientific requirements. Portrait training gives no experience in motion picture or color photography, or in the making of lantern slides, and very little training in the use of the copying camera.

A period of three years of commercial photographic experience is not too long an apprenticeship for those who wish to enter the field of biological photography. A modern commercial photographer must know much about the types of film, and which to select for various kinds of

work. He must be an expert photographic print maker and must know lighting, lenses, copying, lantern slide making, color and motion picture photography, the use of color filters, processing room technique, and the proper use of backgrounds. All this knowledge is important to the biological photographer.

If biological photography is to go forward, it must attract men with the fundamental training necessary to carry on the work with a minimum of error. It should be the aim of every person engaged in biological photography to deliver the very best photograph that can be made. Anything but the very best is a reflection, not only on the photographer, but also on the institution he represents.

By all means, an effort should be made to establish a school of biological photography, where individuals desiring this type of training may obtain it from experts. This journal invites comments from its readers as to how such a school can be organized; the subjects it should teach; requirements for entrance; length of training; and suggestions for organization. Letters on this subject may be addressed to the editor giving the privilege to publish them in full or in part. More will be written about this subject in a later issue.

F. R. HARDING.

PHOTOMICROGRAPHY BY THE FINLAY PROCESS[1]

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The photographic recording of microscopic objects in their full color is a procedure of extreme value to scientific work when the chances of error due to the human element must be kept at a minimum.

Various processes for the photographing of microscopic objects in their full color, so-called "natural color photomicrography," are now used. A description of them would be outside of the scope of this paper and the reader is referred to text books on this subject. (See Reference.)

Those mostly used at the present are the color separation process,

[1] Read at the September 1933 Convention of the Biological Photographic Association.

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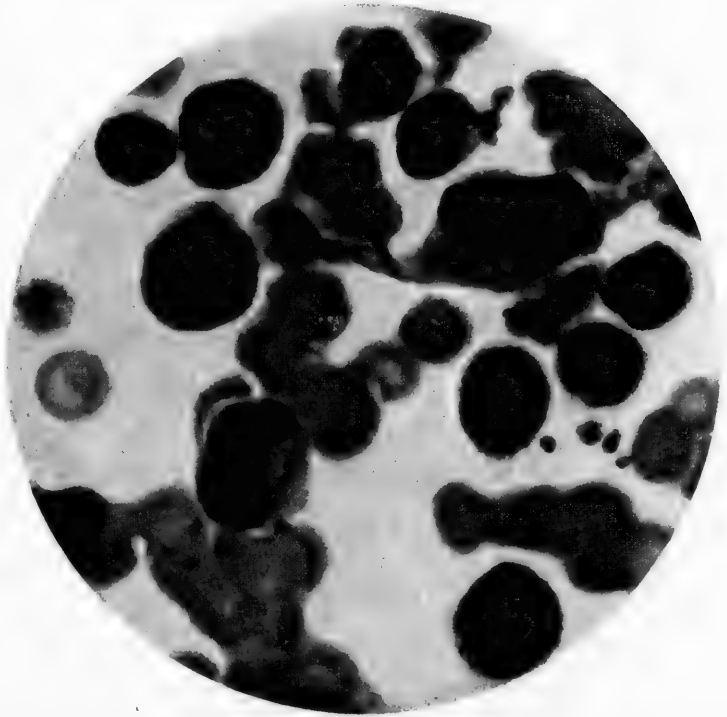
PHOTOMICROGRAPHS BY FINLAY COLOR PROCESS

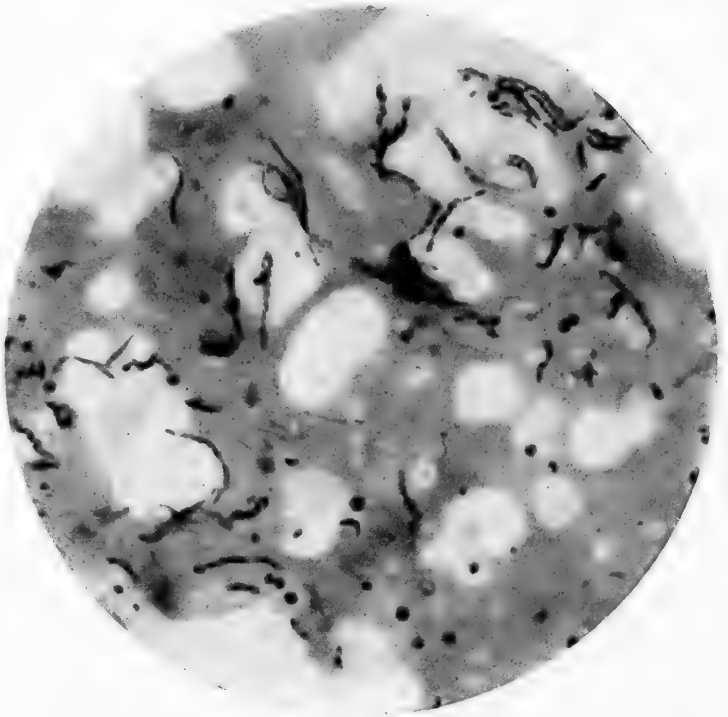


PHAGOCYTIC LEUCOCYTES IN BLOOD—X 1300

WRIGHT'S STAIN—

A preparation about 15 years old in which the colors were faded and very pale. Negative and positive handled for maximum contrast.
Obj. Zeiss Apo. 90—N.a 1.3—Homal III.

From the Collection of DR. ST' WART J. LAWSON



COCCAL DERIVATIVES OF TUBERCLE BACILLI—X 1550

GABBETT'S STAIN—S. J. MAHER'S GLYCERINE BROTH MILK MEDIUM

A very thin bacterial smear. Negative handled for maximum contrast. Positive developed normally.
Obj. Zeiss Apo. 60—N.a 1.4—Homal III.

From the Collection of DR. STEPHEN J. MAHER

PHOTO-ENGRAVING AND PRINTING BY THE BECK ENGRAVING COMPANY · PHOTOMICROGRAPHS BY JEAN KIEFFER

either two or three colors; the combined screen plate; and the separate screen process. The Finlay process comes under the last heading, being an evolution and an improvement on the old Paget process which was in use years ago and which fell into disuse on account of its lack of uniformity and the size of the elements of the screen.

The value of a single negative plate system using separate screens is great, although it must be admitted that the ideal method of reproduction in full color is the three plate separation process. However, its complications, its cost, and the large amount of time necessary for successful results, are great drawbacks in the average laboratory, even in the reproduction of inanimate objects where speed is not an essential factor. The advantages of the separate screen process are that it allows the unlimited production of duplicates from a single negative, that black and white copies may be made from the same negative, that it allows better reproduction for illustrative purposes, and that it has more latitude. Moreover, another advantage of the Finlay process over the starch grain plates is that it permits better resolution and more brilliancy, allowing projection of lantern slides with standard equipment. This is due to the fact that the colored square dots which go to make the Finlay process screens are practically transparent while the starch granules are, at best, only translucent. It is also due to this that the exposure necessary for good reproduction with the Finlay process is much faster than with the starch screen process. In the matter of cost the Finlay process appears more expensive because one successful Finlay color positive will cost approximately three times as much as a successful starch grain screen plate. However, the chances of success with one exposure are much greater with the Finlay process than with the other processes, and in many instances the cost of the finished product has not been much greater. Under certain conditions and for certain types of work the Finlay process will be much less expensive, as a large number of inexpensive positive plates may be kept on file as a matter of record to be combined with the viewing screens only as need arises. In some phases of research one may not know until the experiments have been completed which particular photographic records are of value.

The Finlay process is an additive process of color photography in which the original exposure is made through a taking screen on a fast panchromatic plate as a black and white negative. However, as the screens are made up of very fine regular dots of three colors, the resulting negative

will also be made up of dots of similar distribution and shape. The negative is in black and white, the amount of blackening being dependent both on the intensity, and on the color of the light reaching the plate. From this negative a contact print is made on a glass plate covered with a positive emulsion. The resulting positive is still black and white and made up of dots similar to those of the negative, but reversed as to blackening. When a viewing screen is placed in contact with the positive plate in such a position that the dots are in register (they are of geometrical patterns so that any given group of dots on a screen will exactly cover a similar group of dots on the positive plate) the white light shining through the screen will be split into its different color components, depending on the color of the screen dots through which they pass, and on the amount of silver deposit on the dots immediately behind them in the positive plate. This gives rise to an image similar in light intensity and color value to that seen on the ground glass. A variation of this process is one making use of positive screen plates in which the viewing screen is coated with a positive emulsion, and the finished negative registered with it before making the positive exposure. After ordinary development and fixing, the result will be similar to that obtained by registering the viewing screen and the positive plate. Such a positive screen plate is similar to the finished plates of the starch grain plate processes obtained by reversal, except that, the screen being more transparent, the results are more brilliant and duplicates can be made.

The application to photomicrography of such a system of color photography is particularly valuable on account of its latitude, and the ability of the operator to increase the contrast without altering the color value, a thing which I have been unable to do successfully with the starch grain plate process. For the photographing of fairly thick sections this is not very important, as their inherent contrast is great enough to permit good reproduction by ordinary methods. However, it is invaluable for highly magnified reproduction of thin sections, or bacterial preparations, where contrast is at times very small. In black and white photomicrography this is very easily remedied by the use of contrasting plates and the proper contrast filters, but these artifices are not available in color work. The plate used in color photomicrography is the same as is used for outdoor work where the contrasts are tremendous, and the use of contrast filters is absolutely impossible. To obtain contrast in the

finished product, other methods are available in the Finlay method at different steps in the processing. If used cumulatively, they give such increase in contrast that it is possible to obtain finished plates which are entirely too contrasting. Where properly used they give a range of adjustment which permits the worker to obtain satisfactory results from almost any preparations. Such methods include the use of contrasting developer for the negative supplemented by over-development for preperations of minimum contrast, and the use of developers and positive plates of varying contrast for the positive. The system which I have found most satisfactory will be described further on.

There are other problems in the use of color with which the worker in black and white does not have to contend. The best lens system made has some residual chromatic aberration which is easily eliminated in black and white work by using a filter, but which must be contended with in color work and has a tendency to decrease the resolution. This is particularly noticeable in high power work with objective lenses of wide aperture. Other causes of lessened resolution are the grain of the plates and the size of the dots making the color screens, so that the best color reproductions will not quite equal in resolution a black and white photomicrograph of similar quality. One must decide whether or not the value of the color will compensate for the loss of detail. In some phases of work the answer is unequivocally on the side of color.

I have mentioned the size of the dots in the color screen as a factor in lessening resolution. Strange to say, this appears not to be as great a factor in the Finlay process as it is with some of the starch grain processes, even if the latter's grains are finer than the dots of the Finlay screen. This is due to the fact previously mentioned that the elements in the Finlay screen are transparent, whereas they are translucent in the other screen, the loss of resolution in the latter case, being due to the diffusion of light through the screen. One way to compensate for the loss to a certain extent, if the loss of resolution be due to the grain of the plate and the elements of the screen, is the use of high magnifications on large plates. This is a procedure of choice where illustrations in three or four color half-tones are contemplated. However, it must be remembered that this procedure will not compensate in any way for the loss of resolution due to the imperfect correction of the optical system. If this is bad, nothing can be gained by the use of large plates.

EQUIPMENT FOR PHOTOMICROGRAPHY

A very elaborate equipment is not essential for good results. However, there are a few requisites without which good photomicrography in color cannot be done. The lens equipment of the microscope must be apochromatic. For high magnifications the condenser must be of the achromatic type, as the ordinary Abbé condenser will not give a white background due to the varying foci of the different colors. This can readily be seen by racking a condenser of this type slightly up and down, while viewing the specimen under a high magnification. The light in the background will be seen to change from slightly yellow to slightly blue, and vice versa. Besides this, a clear image of the field diaphragm cannot be had with the Abbé condenser. A field diaphragm is a necessity in order to minimize any surface reflection which takes place in the lens system. In black and white work this only occasions a slight fog, which is not too objectionable under ordinary circumstances, as, by the use of proper printing paper, one can compensate for it. However, this reflected light is white light, and when superimposed on the ground glass image of the object it has the very objectionable effect of diluting the colors. In extreme cases instead of strong color one can obtain only pastel shades. In this connection one should be reminded that dust or dirt on the optical system has the same effect, and that cleanliness is the criterion of successful color photography. Another cause of this dilution of the image with white light is the presence of air bubbles in the oil while doing oil immersion work. One should make it a practice always to look at the back lens of the objective, before setting up the camera, to see if the condenser and the objective are properly immersed. The illuminant is, of necessity, Mazda type on account of its steadiness, its ease of control, and the fact that with the use of the proper condensing filters, white light can be approximated. For the finest type of work it is good practice to have a rheostat and a volt meter in the line, in order that one may always use the same voltage, because the color of a Mazda filament changes with voltage, being bluer at high voltage, and redder at low voltage. This property can be made use of in order to obtain white backgrounds in case the combination of taking screen, compensating filters, negative plate and color of light, does not give colorless backgrounds at the voltage usually employed.

PROCESSING

The photographic processing is standard, and requires no special equipment, except that which is used in registering the finished positive and viewing screen. All processing should preferably be done at 65°F. although the appended table gives correction factors for other temperatures in case it is absolutely impossible to work at standard temperature. Good results have been obtained in working with solution temperature as high as 75°, but the chances of failure are much greater.

Time-Temperature Development

°F.	A	B	C	D
60	6¾	10¾	13½	16
62½	5¾	9¼	11½	13½
65	5	8	10	12
67½	4½	7¼	9	10¾
70	4	6½	8	9½
72½	3½	5¾	7	8¼
75	3	5	6	7¼

A. Normal development. For thick sections of strong color constrast or polarized light work at low apertures (less than N.A 0.5).

B. For thick sections or polarized light work at high apertures.

C. For moderate sections and blood smears.

D. For very thin sections and bacterial smears at high apertures.

EXPOSURE

After the equipment has been checked, and the proper picture obtained on the ground glass, the determination of the exposure is the next point. A negative of the proper printing quality will be obtained for the Finlay process when the exposure given it through its Mazda compensating filter will be equal to that which will give a full exposure on commercial panchromatic film (Eastman), with X-1 filter. The deepest shadow where color is wanted should begin to have a visible silver deposit on the film. The negative plate being softer, a similar exposure will give the proper silver deposit, provided the method of development which follows is used. It must be remembered that this method of gauging exposure is only approximate, and may not give the best possible exposure for Finlay work, but ought to come close enough to give a satisfactory color positive

at first attempt. As the worker gains experience, he may change this factor for better results.

Some photoelectric system of measuring the actinic value of the image on the ground glass may be of help in this instance. Gross and Johnson have described such a system.[2] I am at present experimenting with a simpler system, using a photo-electric cell which requires no energizing current.

The plate is developed in X-ray developer (Eastman) for twelve minutes at 65°. If the plates are fresh, this overdevelopment will not cause fog. This twelve minutes is for the thinnest preparation, for instance, bacterial smears. For sections of medium thickness, ten minutes should be used, and eight minutes for the heavier sections. These various developing times will compensate for the varying contrast, so that negatives of similar quality should be obtained.

At the end of development the plate is rinsed in an acid stop bath (water 1000 mls., glacial acetic acid 15 mls.); and then put in a regular acid fixing bath (Eastman F-1) where the plate should be allowed to remain until thoroughly hardened, which should take ten minutes with a fresh bath. The use of a stop bath, and a fresh fixing bath, will minimize any tendency of the emulsion to shrink. The plate is then washed thoroughly for an hour, and before drying, is wiped on both sides with a chamois, lightly on the emulsion side, although after hardening the emulsion will stand fairly rough handling. It is important that no drops be left on either side, as a drop of water on the glass side may so change the rate of drying of the emulsion opposite it, that it may give rise to a drying mark with local loss of register. A current of slightly warm air is a help. Before printing the positive, the edge of the negative plate must be examined for loose or frilled emulsion, and any such defect removed with a sharp knife, as this would prevent good contact between the negative and the positive during printing. The printing light is, of choice, a projected light such as that coming from an enlarger. Besides being of approximately the right intensity, such a light will minimize parallax. The exposure will be approximately equal to that necessary for a bromide enlargement, from the same negative, with the enlarger at the same setting.

It is at this point that further control in contrast of the finished proc-

[2] Volume 1, No. 4, The Journal of the Biological Photographic Association.

uct can be obtained by the use of positive plates of different contrasts, and of different developers. I have found only two plates satisfactory so far, the Ilford Special Finlay Positive Plate and the Hauff Contrast Lantern Slide Plate. The Hauff is a softer plate than the Ilford. The negatives obtained by the method above outlined will usually give a good quality positive on Hauff plates using contrast developer, or on Ilford plates using X-ray developer. The exposure necessary for similar results on both plates is about the same, the Ilford being perhaps a little faster. If more contrast is wanted an Ilford plate developed in contrast developer will give it; if a softer result is wanted, a Hauff plate developed in X-ray developer is best. The time of development at 65° is one minute in contrast and one and one-fourth minutes in X-ray developer respectively. Varying this development time will give further slight control in contrast. The contrast developer I use is the regular Eastman Process Developer (D 9) to which 2 grams of anhydrous sodium sulphite are added to each 100 mls. of developer just previous to use. It improves its keeping quality and the color of the positive. This developer should not be used after it has become noticeably brown (the color of amber). When working with contrast developer it is essential that the temperature of the developer be not over 67°F. or softening of the emulsion, with subsequent lack of register, may ensue. The stop bath and the fixing bath are used the same as for the negative. The washing may be shortened to half an hour. The plate is wiped and put up to dry the same as the negative plate. The positive of the right density will, before fixing, when looked at in a white tray by reflected safe light, have the appearance of a slightly dark print. I have found it good practice to develop to the point where the appearance will be that of a print which is just definitely too dark, and then clearing the positive in a weak Farmer's reducer to bring it back to the proper density. This is best done after the plate has been washed, dried and temporarily registered so that a good idea of the amount of reducing necessary can be had.

The permanent mounting of the positive plate and the viewing screen after they are properly registered, (for method of registration see Finlay instructions) is done in the manner similar to that used in mounting lantern slides with cover glass. Extreme care must be taken in order that registration be not lost. I have found the following method of mounting to be very convenient and to prevent subsequent shifting even after rather rough handling of the finished slide. Before final registration the

corners of the positive plates are broken off with the help of a pair of pliers, diagonally across, for a distance of about one-eighth of an inch. After this the plate must be very carefully brushed with a camel hair brush in order to remove all small glass chips. The plate and the screen are then registered, a strong clip put on each edge and the whole clamped securely in a lantern slide vise. Care must be taken when tightening the vise or registration may be lost. A small amount of sealing wax, stick shellac, or similar material (I have found that South Bend Fish Rod Cement works best) is then made molten with the help of a Bunsen Burner, on the corners of the screen, thus filling the corners of the positive plate which have been chipped off. This is done on all four corners. As soon as the cement has hardened the slide can be removed from the vise, the clips taken off, and the registered screen and plate handled freely without fear of losing registration. The surplus cement, if any, is scraped off with a knife, and the slide bound, in the ordinary way, with half inch paper binding tape. The new adhesive cellophane is not satisfactory. In very warm weather, or when the slide has warmed up during projection, it may allow shifting. Any necessary matting must be done on the outside by pasting the matting to the cover glass. Positive screen plates may be handled as regular lantern slides.

DIFFICULTIES

Although the method I have outlined will give very satisfactory results, difficulties are liable to be encountered at the beginning. Imperfect color, due to uneven register, may arise from various causes, the most common of which is the local shifting of the emulsion on either plate, caused by the softening of it, due to the very alkaline developer employed. The temperature may be too high, or the acid fixing bath not fresh, or the rinsing in the stop bath too short. Prolonged holding of the plates in the hand for inspection during development or fixing, is also apt to cause shifting of the emulsion near the edges, even if all other precautions be taken. Unevenness of drying may also cause shifting.

Lack of contact between the taking screen and the negative plate, or between the positive plate and the viewing screen will cause a general shifting of color. As the worker gains experience, he will quickly recognize the cause of lack of register. (For further details see Finlay instructions.)

If unsatisfactory contrast is obtained in the finished product, it can

usually be corrected by changing the method of making the positive, using softer plate or softer developer, or both if the contrast be too strong. Also more contrasting plates or developer if contrast be lacking, may be used. In my experience, these various manipulations have not changed the color. Occasionally the worker may find that the colors in the finished plate are not the true colors of the specimen, even with a correctly exposed and processed negative. In such cases, usually, the color of the taking screen is at fault. This will be particularly true if the screens are old, for two reasons: first, some of the early screens available were not uniform; second, the screens may fade slightly if exposed to strong light. (Particular care must be taken not to expose taking or viewing screens unduly to strong light or daylight.) In such cases, one can usually obtain satisfactory results, by changing the color of the light reaching the negative through variation of the filament voltage of the illuminant. This has been touched upon previously in this paper. One can also make use of a different compensating filter, or a combination of filters. With some old screens I have obtained the best results by using both the Mazda and the Blue Daylight compensating filter, together, in the illuminating beam. Occasionally, if the color of the finished product be very blue, the Photo Flash filter can be used instead of the Mazda filter. If other compensating filters than the Mazda are used, exposure must be changed accordingly. The factors are approximately as follows:

Mazda Filter	1
Mazda plus Blue Daylight Filter	1½
Photo Flash Filter	¾

It goes without saying that change in the voltage of the illuminant will cause corresponding change in the necessary length of exposure. Using a 6 volt flat filament Mazda lamp at the normal voltage, the exposure will be approximately doubled, if the voltage be dropped to 5.4 volts.

Once correct color values have been obtained with a given combination of light, filters, taking screens and negative plates, no further changes will be necessary. However the sensitivity of a panchromatic emulsion for the different colors may change with age, and slight adjustments may be found necessary, if the plates are used only occasionally, or if a package of plates of a different emulsion number is used.

Another cause of poor color in the positive, and one very much more

easily remedied, is bad color in the viewing screen. This is readily recognized, and is due usually to changes produced by prolonged exposure to strong light or daylight. Under such conditions the screen takes on a yellowish green hue. The remedy is obvious—do not use the screen; however, screens which show only a slight variation from neutral gray, can occasionally be used to correct slightly unbalanced color values in the positive. For instance, if registration with a neutral gray screen gives a finished product tending toward the red, a slightly greenish screen will give more satisfactory color value, although in such cases the background may not be pure white.

I hope that the enumeration of these difficulties will not make this process seem too difficult and deter anyone from attempting it. They are only given to smooth the way, and to enable the worker to attain more quickly that which he seeks—the photographic reproduction of microscopic objects in their true colors.

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THE PRINCIPLES OF THREE-COLOR PHOTOGRAPHY

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All practical processes of color photography may be divided into two classes,—the additive and the subtractive. The first of these is based upon the fact that every known hue can be produced by mixing light of three primary colors in the proper proportions. These colors are a pure red, a pure green, and a pure blue.

By taking monochromatic lights of these colors, it has been determined in what proportions they must be mixed in order to produce the sensa-

tions of all the colors in the spectrum. The results may be expressed graphically by means of three over-lapping curves called the tricolor sensation curves (fig. 1).

The monochromatic lights used to determine these curves are obtained by prismatic dispersion or diffraction of white light, and the selection of three very narrow regions of the spectrum. Such a procedure is much too wasteful of light for practical color photography. It is, nevertheless, possible to pass beams of white light through color filters in order to obtain red, green, and blue light, and afterwards to recombine these

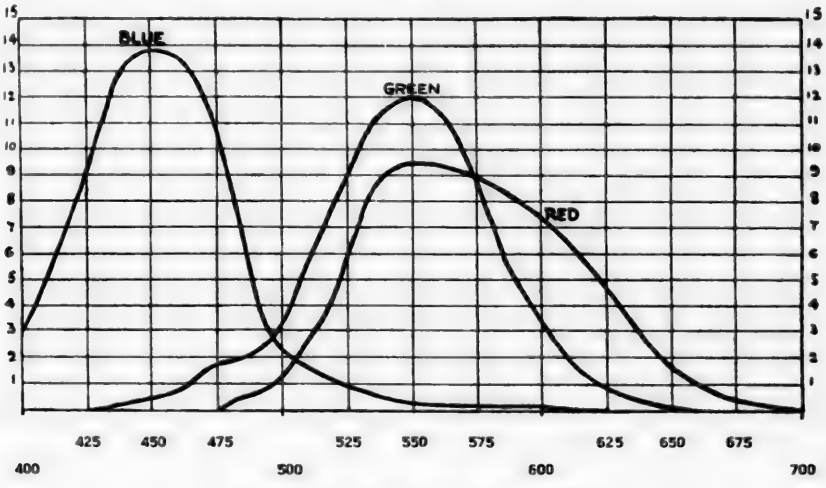


FIG. 1. TRICOLOR SENSATION CURVES

lights in the correct proportions to reproduce any color. Although the tricolor sensation curves no longer hold for colors obtained in this way, the results are quite satisfactory. In "additive color synthesis," yellow is produced by adding together red and green light, magenta by adding red and blue light, and blue-green by adding blue and green light. White is produced by adding light of all three colors in the right ratio. Black is produced by the absence of all three colors.

In the additive process of color photography, what is necessary is to take three photographs of the subject through red, green, and blue filters. For this purpose, we must use a material that is sensitive to all colors of visible light, in other words, a panchromatic plate or film.

Prints on lantern slides or film may now be made from the three nega-

tives. The three positives so obtained form a record of the relative intensities of the primary colors present in different portions of the subject. If these prints are placed in a triple lantern, and the print from the red filter negative is projected with the red beam, the print from the green filter negative with the green beam, and the print from the blue filter negative with blue beam, the three images being superimposed on the screen, a reproduction of the subject appears in color.

It will be seen that in additive projection, the white light is first separated into beams of the three primary colors by means of filters, and light of these three colors is then *added* together, in various proportions in the different areas of the picture. These proportions are controlled by means of thee neutral positive prints, placed in the beams so as to absorb more or less of the light of each color going to the screen.

For making prints on paper to be viewed by the ordinary light of the room, a different method of printing is used, although the method of taking the negatives is the same. This printing process is based upon the subtractive principle of color formation.

According to the subtractive principle, three dyes, or pigments, are used which are complementary in color to the primary colors that make up white light. Of these complementaries, each owes its color to the absorption of only one of the primary colors and the transmission of the other two. The subtractive dyes or pigments are therefore blue-green or minus red, which absorbs only red; magenta or minus green, which absorbs only green; and yellow or minus blue, which absorbs only blue.

The other colors are formed by the superposition of the complementary dyes, or pigments, in varying concentrations. Red is formed where yellow and magenta overlap; since the yellow absorbs blue and the magenta absorbs green, only red is left. Green is formed where yellow and blue-green overlap, and blue is formed where blue-green and magenta overlap. Where all three colors overlap, black is formed, since no color can get through. White is, of course, represented by absence of all three colors.

In subtractive printing, three positive prints are made from the three negatives, but these, instead of being printed as black and white images, as in the additive process, are dyed or toned in the three subtractive colors. The print from the red filter negative is dyed blue-green, the print from the green filter negative is dyed magenta, and the print from the blue filter negative is dyed yellow. It should be noted that it is the

positive image which is dyed in proportion to its density, and not the entire surface of the film. When the three dyed images are superimposed, a picture in natural colors is formed.

The subtractive process is adaptable not only to making prints on paper, but also to making lantern slides and motion picture films. For these purposes, the subtractive process has the advantage of requiring only an ordinary lantern or motion picture projector without any alterations, but the printing is usually more difficult than in the additive process.

In the subtractive process, then, white light is used for viewing, and three prints are superimposed, each of which selectively absorbs from the white light, one of the three primary colors in varying proportions according to the absorption of the original subject for these primary colors.

We may now proceed to consider a few of the many types of apparatus, materials, and chemical processes with which color photography is actually practiced.

In the first place, the camera may be of the type in which the exposures of the three negatives are made in succession. With such a camera, if the subject moves, it will be taken in a different position on each of the negatives, and the result will be color fringes in the finished print as well as a blurring of the image. Various cameras have therefore been devised which expose all three negatives simultaneously.

In the Gaumont camera for motion picture work, three lenses are arranged, one closely above another, which take the three pictures in three quarters of the space required for the same number of frames of an ordinary motion picture. The three exposures are made simultaneously through the three filters, and then the film is pulled down three frames instead of only one.

This arrangement of lenses is not suitable for making larger negatives, however, since the separation between lenses becomes so great that the negatives are made from different points of view. This condition which is called stereoparallax results in color fringes in the print.

One type of still camera which exposes the three negatives not only at the same time but also from the same point of view is the Butler camera (fig. 2). Figure 2 is from the drawing accompanying Butler's description in the "Photographic Journal" of 1905. The lens is placed in the front of the camera at the right of the drawing. *a* is an unsilvered plate glass reflector which reflects a portion of the light through the filter

f onto the plate *c*. The major portion of the beam passes through *a* to another reflector *b*, where a portion is reflected upward through filter *g* onto plate *d*. The remainder of the beam passes through reflector *b* to plate *e*.

Dr. Mees, in 1908, published in the "Photographic Journal" the arrangement of filters most efficient for the panchromatic plates of that day. This arrangement is not the best for Wratten Hypersensitive Panchromatic plates, however, on account of the great increase in speed, especially to red and green light.

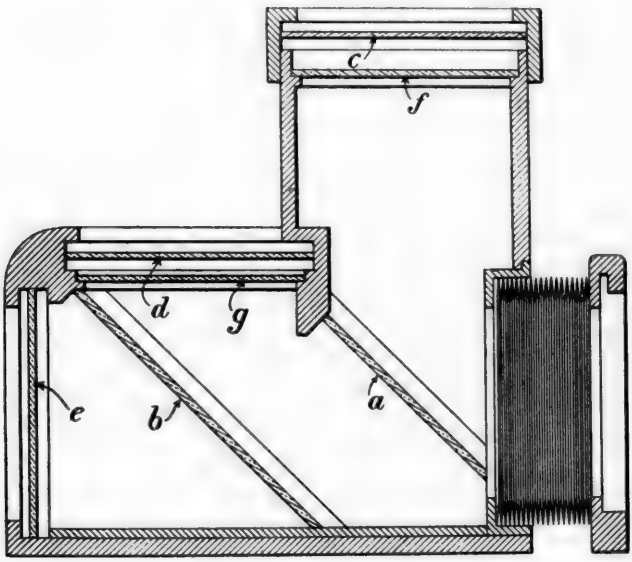


FIG. 2. BUTLER CAMERA

When these newer plates are used, the filter placed at *f* is green, Wratten no. 58. The filter at *g* is red, Wratten no. 25. The rear plate *e* is used for the blue record, but needs no filter of its own. The reason is that the second reflector *b* consists of two pieces of optical plate glass with a blue filter, Wratten no. 49, cemented between them. The first reflector *a* likewise consists of two pieces of optical plate glass, but with a special minus green filter cemented between them.

The purpose of the minus green filter in the first reflector is to absorb the green light reflected from the rear surface of this reflector, which

would otherwise give rise to a double image on the green filter negative. Similarly, the blue filter in the second reflector absorbs the red light, reflected from the rear surface, which would give rise to a double image on the red filter negative.

The green filter glass must be $\sqrt{2}$ or about 1.4 times as thick as the first and second reflector glasses combined, and the red filter glass must be 1.4 times as thick as the second reflector. This is necessary to make the optical paths through glass the same for all three beams.

This arrangement of filters is the most efficient by both daylight and tungsten. It is necessary, by either light to adjust the exposures through the three filters so that equal densities are obtained in all three negatives for white or grey objects. This is done either by placing neutral densities behind the red and blue filters or by using a suitable greenish filter over the camera lens. Naturally, the corrections are different for the two kinds of light.

One of the most suitable color processes for both amateur and scientific use employs an ordinary camera, however, and is free from color fringes due either to motion or stereoparallax. It is known as the screen-plate process. The oldest example of this in use today is the Autochrome. The Finlay plate is similar in principle.

The Autochrome plate is coated with a mosaic screen of microscopic red, green, and blue filter elements consisting of dyed starch grains. The layer of grains is covered with a thin film of waterproof varnish and then coated with a panchromatic emulsion of high resolving power. The plate is placed in the camera with the glass side facing the lens. A yellow filter is placed over the lens to correct for the excess blue speed of the emulsion, which is rather slow to red and green light. When the exposure is made, the light coming through the starch grains exposes the emulsion behind each separate colored grain according to the amount of light of that color in the corresponding portion of the image formed by the lens. The plate is now developed to a negative, but, instead of being fixed, it is submitted to a solution of potassium permanganate and sulphuric acid which oxidizes all of the developed silver to a silver salt which dissolves out in the solution. There is now left on the plate only the silver bromide that was not developed. This is converted to a positive silver image by exposing the plate uniformly to light and developing again. A positive image in colors may now be seen by looking through the plate or projecting it onto a screen.

It is evident that the screen plate process is an additive process, since white light is separated into its primary colors in passing through the screen, and recombined on the retina of the eye in proportions governed by the density of the silver image on the emulsion.

A motion picture additive process which bears a close relation to the screen plate, but which forms the screen elements by optical means, is the Kodacolor process. Kodacolor film is embossed on the support side with an enormous number of cylindrical lens elements, 22 to the millimeter. When the film is placed in the camera with its support side facing

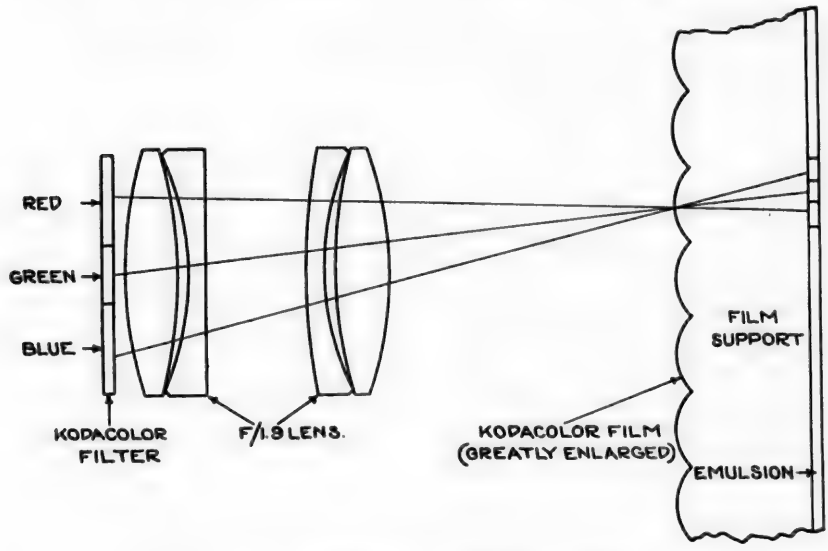


FIG. 3. DIAGRAM OF KODACOLOR PROCESS

the light (fig. 3) each lens element forms, on the emulsion behind it, an image of a tricolor filter placed over the camera lens. The film is exposed, developed, and reversed somewhat as described for the Autochrome plate. It is then placed in a projector which has, over its lens, a filter similar to the camera filter. Each minute lens element on the film now forms, on the tricolor filter, an image of the color record in developed silver which is present in the emulsion layer behind it. Thus, the silver image determines the amount of light passing through the tricolor filter from each part of the picture. An additive picture in natural colors is produced on the screen.

The various chemical processes by which subtractive prints are made are too numerous to describe. One of the simplest is the bichromated gelatin process. A lantern plate, without fixing, may be bathed in a dilute solution of ammonium bichromate, and dried. It is then exposed for several minutes from the glass side, in contact with a negative, to parallel light from a carbon arc or a 500-watt incandescent tungsten lamp with clear glass. If the plate is now washed in warm water at about 45°C., the gelatin dissolves away from the glass in the highlights, but is left in the shadow portions in varying thicknesses according to the density of the shadows in the subject. A gelatin relief image is thus produced. The silver bromide is now fixed from this image and the plate is immersed in a water solution of a suitable dye. The dye is taken up by the gelatin in amounts proportional to its thickness, so that a transparent dye image is produced. Three such slides can be printed from a set of three-color negatives and dyed with the complementary colors. Since the plates are difficult to superimpose in register, however, it is better to make two of the prints on plates, reversing one of the negatives in the printing, and to make the third print on a thin film. The thin film is then bound up between the two plates with their gelatin sides turned inward. The result is a lantern slide in natural colors.

For many purposes, however, particularly in photomicrography, two colors are sufficient to reproduce the subject with reasonable accuracy. Negatives are then taken through two filters only, which are suitably chosen, and the two bichromated gelatin prints on lantern plates are dyed in colors roughly complementary to the taking filters. If printing dyes are selected to match the stains, microscopic specimens may often be reproduced in this way very satisfactorily.

Two-color printing has also been applied to motion picture film on account of the simplification which it affords. The prints can be made on double coated film, that is, film with an emulsion layer on each side. When the images on the two sides are suitably dyed, the results are satisfactory for many purposes.

Three-color prints on paper are made by a number of processes, practically all of which require considerable manipulative skill and knowledge of the conditions influencing the photographic reproduction of light intensities. In the three-color carbon process, gelatin is employed in which insoluble pigments are incorporated before coating. The pigmented gelatin is coated onto paper support in a form known as "carbon

tissue." This is sensitized by bathing in ammonium bichromate, and exposed for several minutes to a strong light, on the gelatin side, instead of through the support. Since the insolubilized image therefore lies on the surface, the tissues must be washed in cold water, and squeegeed face-down onto a temporary transparent film support before developing in warm water. After the three pigmented prints are developed on three separate supports, they may be superimposed by stripping them one at a time onto gelatin coated paper. This process of transferring the prints to temporary supports for development, and afterward superimposing them on paper, is known as the double-transfer process.

For printing in the enlarger, the three-color carbon process is not very suitable, on account of the slowness of the bichromated tissues. Some other process is therefore preferred in which prints can be made on bromide paper or film by the developing-out process.

In the three-color "Carbro" process, pigmented gelatin tissues are soaked in a bleaching solution and squeegeed onto bromide paper prints. The essential ingredients in this bleach are a bichromate, a bromide, an acid, and either a ferricyanide or a cupric salt. Its function is to oxidize the silver image to one of silver bromide, and to tan the pigmented gelatin in contact with the silver image as a result of the formation of a chromic salt in the gelatin. The tanned images are washed, developed on a temporary support, and transferred onto paper as in the three-color carbon process.

It is possible also to print from the negatives onto yellow dyed film by exposure through the support, and to produce a tanned image either by developing in a tanning developer, which contains very little sulphite, or by developing in any clean working depth developer and bleaching the image in a tanning bichromate bleach. The tanned image may be developed on its original support to a relief image in warm water and stained with a suitable dye. Three dyed reliefs may then be brought, one at a time, into contact with a sheet of moist gelatin-coated paper, whereupon the dyes are transferred to the paper. The reliefs may be redyed a number of times and additional prints made. This process is known as the three-color imbibition process.

MODERN DARKROOM PRACTICE

J. I. CRABTREE AND G. E. MATTHEWS

From Kodak Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

A darkroom should never be any larger than necessary. Its size is limited, naturally, by: the volume of work to be done in the room; the number of persons working therein; and the number of pieces of equipment which must be used there. Everything should be arranged conveniently to facilitate ease of working. Storage space should be provided for all apparatus when not in use, and each piece should be clean when put away. The walls should be painted light gray, green, or white, with

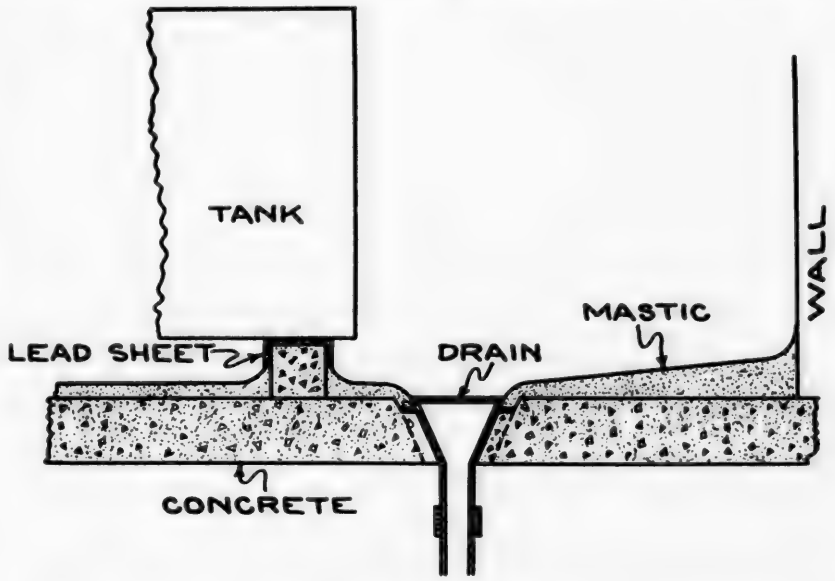


FIG. 1. DETAIL OF FLOOR, TANK SUPPORT, AND DRAIN CONSTRUCTION

a semi-gloss paint which can be washed easily. Where chemicals may be splashed on the wall a chemically resistant paint should be used.

The floor should be constructed of a material which will permit easy washing. Hard rubber tile laid down on roofing paper with water-proof cement represents a good covering for wooden floors, and hard mastic (asphalt plus sand) over a concrete floor. A drain should be provided, an effective design being shown in Figure 1. If large tanks are to be

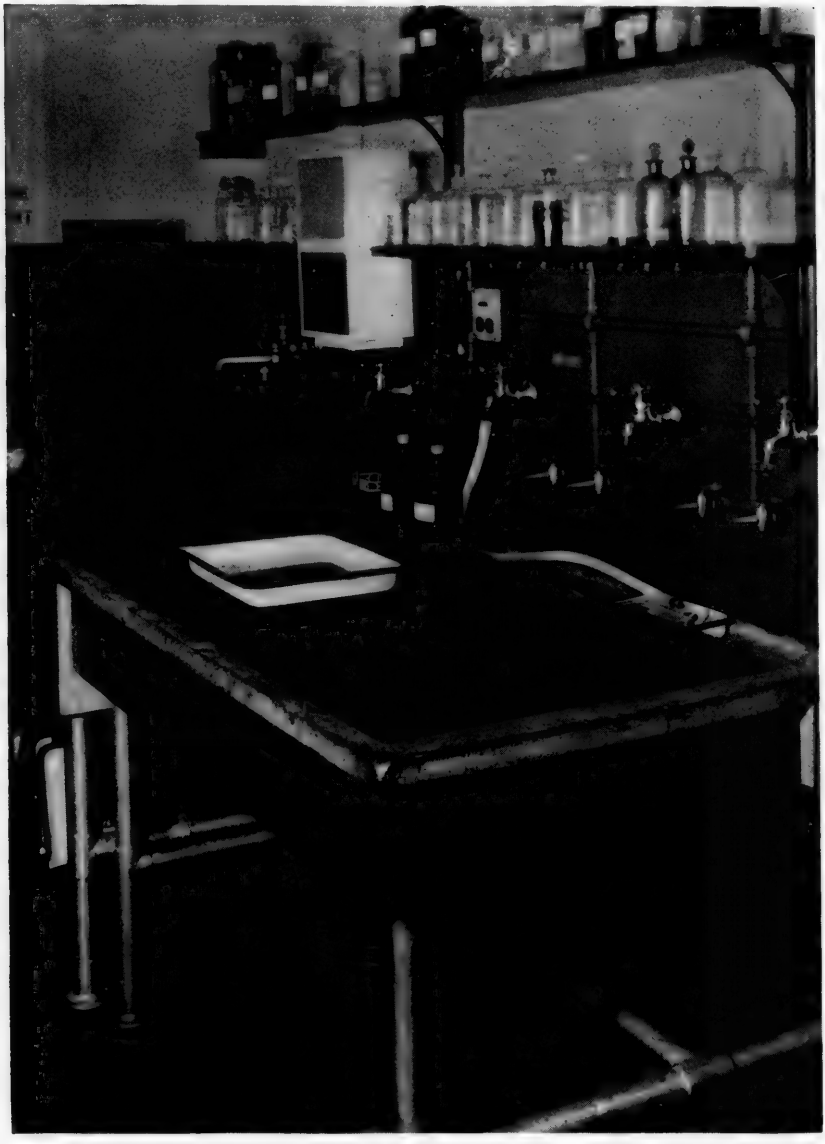


FIG. 2. DARKROOM SINK SHOWING SUPPORT AND SERVICE INSTALLATION
Note rubber matting on Alberen stone ledge

used, they should rest on concrete blocks covered with a strip of sheet lead bent over the sides in the manner shown. No tank or sink supports should rest directly on the mastic floor as they will gradually sink through the mastic, and cause leaks.

Sinks should be of ample proportions, and piped with hot and cold water. Wood covered with lead sheeting (burned joints) or preferably Alberene stone, represent satisfactory construction materials. A typical installation is shown in Figure 2. Note the sink support made of piping. A water mixer represents a useful means of delivering water at a definite temperature.[1] It may be used to flow water at a certain temperature through a water bath around the solution tanks. It will maintain the temperature of the discharged water within $\pm 2°F$.

An excellent covering for all stone surfaces is ordinary black corrugated rubber matting. This should be cut to fit the bottom of the sink and the drain ledge. Compartments for tray storage may be provided under the sink and ledge.

Bench tops are best constructed of wood such as hard maple, and covered either with battleship linoleum, or left bare. In either case, they should be rubbed down with several coats of a hard floor wax. Hard rubber sheets cemented down with a water-proof cement also represent a satisfactory bench top covering. An opal plate glass, known as Vitrolite, has been used to a limited extent for sink ledges and drain boards. It is easy to clean, and resists chemical attack quite well.

The drying of films and plates is best accomplished by installation of a suitable cupboard. This should be equipped with a fan which blows air downward through a cloth filter. Several degrees of heating by means of electric coils can be arranged. A vertical, movable, baffle plate should be installed inside, in order that the size of the inner compartment may be varied, thereby controlling the velocity of the air current.

The installation of suitable safelights in a darkroom is an important matter. Overhead safelights may either be of the direct or indirect style. Bench or sink safelights may be fastened permanently to the wall, or arranged to be moved. The degree of safety of a safelight, to a specified sensitive material, may be determined by exposing the material, for various times, at a known distance from the safelight. This is accomplished by covering a strip of film with a piece of cardboard and moving the

[1] Manufactured by Fulton Sylphon Co., Knoxville, Tenn.

card along an inch or so after each exposure until the material has received several exposures. The film should then be developed for a standard time, and temperature, whereupon a record will be obtained, from which the time of exposure that is safe may be determined.

It is very convenient, and often important, to be able to duplicate exposures when printing in a darkroom. For this purpose, a rheostat should be included in the lamp circuit, and a voltmeter attached across the lamp terminals. Voltages should be a little below normal, say, 105 volts. Fluctuations in line voltage result in serious changes in exposure; a drop from 110 to 100 volts may almost cut the intensity of the lamp in half.

Every darkroom should be well ventilated. A 10-inch propeller fan will handle about 300 cubic feet of air per minute, and is large enough to give adequate ventilation in a room containing 4000 cubic feet of air. Proper air circulation insures comfort, and greater efficiency of the occupants of a darkroom.

Refrigerating units of small size are now available at a reasonable cost, and it should be possible to utilize such units for controlling the temperature of the air in darkrooms.

The mixing of photographic solutions. Chemicals for photographic work should be purchased from reputable manufacturers of chemicals. Much trouble from processing difficulties can be avoided, by using only pure chemicals, especially prepared for photographic service. Whenever possible, the chemical mixing room should be a separate room from the darkroom, in order to avoid trouble from chemical dust settling on moist films or plates, thereby causing spots. Dry chemicals should be labelled carefully, and stored in a definite place, with the lid or cover securely in place.

For the smaller user of photographic chemicals, who requires only a few quarts of solution, a scale weighing 4 or 5 ounces (120 to 150 grams) is satisfactory. For larger users, scales weighing several pounds may be required. Although the avoirdupois system has been used largely by photographic workers for many years, the metric system is simpler, and is coming into greater use. Table 1 is a useful conversion table.

Photographic solutions should be mixed according to the directions of the manufacturer. The order of the chemicals should be followed when dissolving them, and finally water should be added to bring the solution up to a definite volume. Most photographic solutions may be prepared

TABLE 1

Weights and Measures—Conversion Tables

In photographic practice, solids are weighed and liquids are measured either by the Avoirdupois or the Metric system. The following tables of weights and measures give all the equivalent values required for converting photographic formulas. The tables do not apply, however, when converting British Imperial measure to metric.

Avoirdupois to metric weight

POUNDS	OUNCES	GRAINS	GRAMS	KILOGRAMS
1	16	7000	453.6	0.4536
0.0625	1	437.5	28.35	0.02835
		1	0.0648	
	0.03527	15.43	1	0.001
2.205	35.27	15430	1000	1

U. S. liquid to metric measure

GALLONS	QUARTS	OUNCES (FLUID)	DRAMS (FLUID)	CUBIC CENTIMETERS	LITERS
1	4	128	1024	3785	3.785
0.25	1	32	256	946.3	0.9463
		1	8	29.57	0.02957
0.000975	0.0039	0.125	1 (60 mins.)	3.697	0.003697
		0.03381	0.2705	1	0.001
0.2642	1.057	33.81	270.5	1000	1

Solid conversion values

Grains per 32 ozs. multiplied by 0.06847 = grams per liter
Ounces per 32 ozs. multiplied by 29.96 = grams per liter
Pounds per 32 ozs. multiplied by 479.3 = grams per liter

Grams per liter multiplied by 14.60 = grains per 32 ozs.
Grams per liter multiplied by 0.03338 = ounces per 32 ozs.
Grams per liter multiplied by 0.002086 = pounds per 32 ozs.

Liquid conversion values

(U. S. System)

Ounces (fluid) per 32 ozs. multiplied by 31.25 = cubic centimeters per liter.
Cubic centimeters per liter multiplied by 0.032 = ounces (fluid) per 32 ozs.

with water at a temperature of 70° to 80°F. (21° to 27°C.) but dissolution is effected more rapidly at 125°F. (52°C.). There is little advantage to

be gained by using water at a higher temperature, as the rate of solution is only slightly greater, while there is the disadvantage that a longer time is required to cool the solution down to 65° or 70°F. (18° to 21°C.) before it can be used.

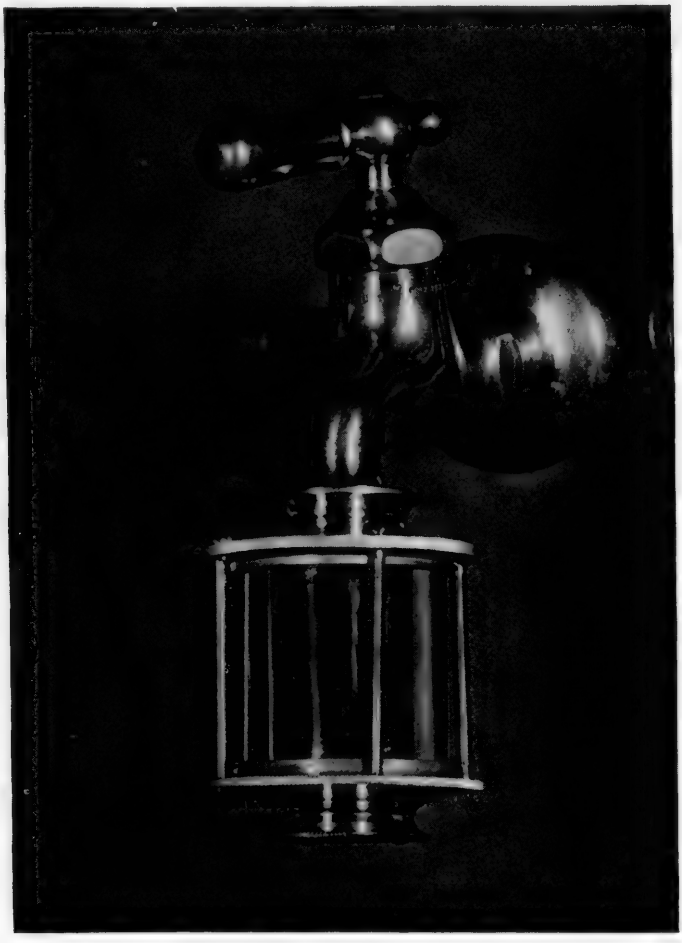


FIG. 3. WATER FILTER ATTACHED TO ORDINARY FAUCET

It is good practice to filter all solutions before use, to remove any particles of dirt, or other foreign matter, which later would settle on the films, and produce spots. This can be done very easily by using several thick-

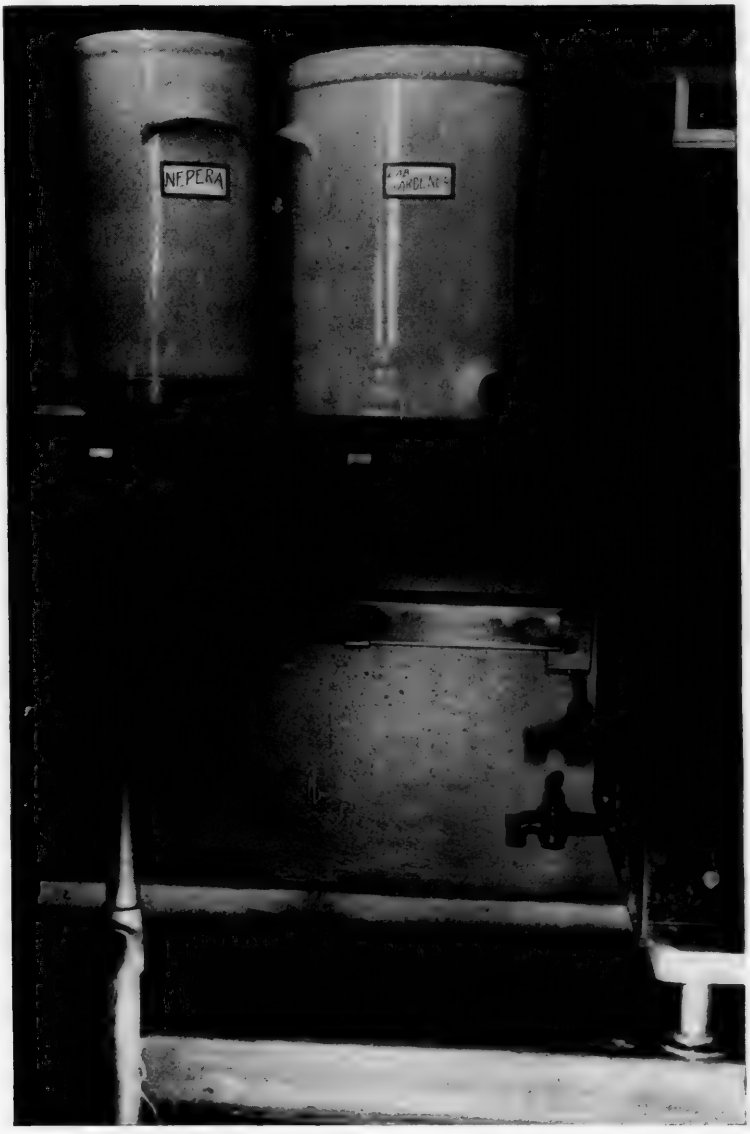


FIG. 4. HARD GLAZED STONEWARE CROCKS FOR STOCK SOLUTION STORAGE
Note types of outlets, drainage pan, and tank support

nesses of muslin, held in place in a glass funnel. If there is very much organic matter in the water supply, it may be desirable to install a simple water filter such as the one shown in Figure 3, which is fitted with a fine wire screen and a felt pad at each end, and is filled with fine sand.[2] Whenever possible, distilled water should be used for mixing solutions.

Enamel pails, or hard rubber buckets represent satisfactory mixing vessels. Stirring rods should be of glass, 18–8 stainless steel, or hard maple. After the stock solutions are mixed and filtered, they should be stored in hard glazed stoneware crocks of the type shown in Figure 4. Note the stainless steel drip tray, and the type of outlet. The hard rubber faucet on the larger crock is to be preferred, as it is not subject to chemical attack, may be removed and cleaned with ease, and will not break easily, provided it is inserted through a soft rubber stopper, in the manner shown. Note also the floor sink to facilitate flushing out under the larger tank, shown on the right.

Suggestions on using photographic solutions. It is standard practice to develop negative materials at 65°F. (18°C.) and positive materials at 70°F. (21°C.) and any great departure from these temperatures means that the likelihood for trouble is increased. As the temperature rises, the developer fogs sooner, blisters are more likely to form in the rinse or fixing baths, and stains may be produced. It is important, therefore, to control the temperature carefully.

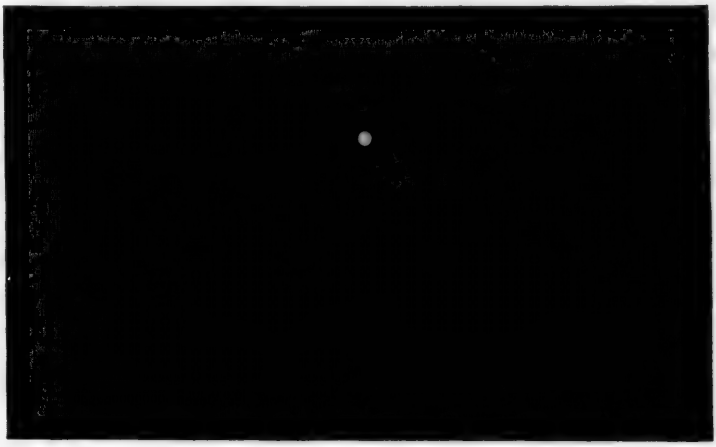
The importance of agitation of photographic materials during processing, cannot be stressed too strongly. Convection currents are set up in a developer, as a result of the formation of reaction products in the solution. If the solution is not moved around, these reaction products tend to restrain development locally. Agitation will largely offset this effect, and will also prevent formation of developer mottle. Agitation also speeds up development.

More rapid removal of the developer from the film results when the film is agitated on immersing in the rinse bath, and the formation of scum and stains in the rinse, and fixing baths, is also avoided by agitation.

A convenient device for handling a batch of a dozen or more films simultaneously, and insuring more uniform development, fixing, and washing is the Eastman Film Developing Hanger. It consists of a

[2] Manufactured by the Jones Manufacturing Co., Boston, Mass.

metal cage, having notched edges along the top ends and sides for holding the film hangers. The rack holds seventeen 8 by 10 in. hangers or twenty-five 5 by 7 in. hangers.



A

B

FIG. 5. MARKINGS CAUSED BY FAULTY PROCESSING
A, Air bell; *B*, drying marks from drops of water

Spots and marks. Most of the markings and stains occasionally produced on films during processing may be avoided by observing three simple rules as follows:

(1) Maintain the temperature of all solutions as near 65° to 70°F. (18° to 21°C.) as possible.
(2) Discard a solution as soon as it shows signs of becoming exhausted.
(3) Agitate all materials when first immersing in any bath, and at intervals during treatment.

A few examples of typical markings which can be prevented by following these rules may be of interest.

Airless bells. Bubbles of air, trapped at the film surface, prevent access of developer to the emulsion, and cause white spots in the fixed-out film as shown in Figure 5A. By immersing the film slowly in the developer, and agitating vigorously as soon as immersed, such markings can usually be avoided.

Scum formation should be carefully guarded against, because even the slightest trace of a surface deposit is picked up when the film is immersed in the solution. A typical scum marking may be caused by the silver salts in the bath reacting with traces of hydrogen sulfide gas in the air, forming silver sulfide, which floats on the surface, and is picked up by the films. Every tank containing developer or fixing bath should be skimmed each morning with a strip of blotting paper, or a few layers of cheesecloth on a frame, in order to remove traces of scum.

Blisters are caused by the formation of gas bubbles within the gelatin film, when the film is transferred from the developer to the fixing bath. The gas forms when the acid of the fixing bath reacts with the carbonate of the developer. If the gelatin is strong enough to withstand the disruptive action of the gas, no blisters will form, but if the gelatin is swollen and in a soft condition, the membrane will burst leaving a tiny pit. Blisters may largely be prevented by maintaining the temperature of the solutions around 65°F. (18°C.), by rinsing thoroughly in water between developing and fixing, and by agitating the film when first placed in the fixing bath.*

Tear drops or drying marks. If drops of water are left on the film during drying, and especially if the drying temperature is excessive, the gelatin does not shrink uniformly, and markings are produced similar

*The new non-blistering alkali, Kodalk, recently announced by the Eastman Kodak Co., has the advantage over carbonate that it does not generate a gas when added to an acid solution. Blisters may therefore be eliminated by using developers containing this alkali.

to those shown in Figure 5B. If films are wiped carefully with a chamois, and allowed to drain a few minutes before the drying air is turned on, formation of these markings can be prevented.

Photographic troubles will be few, and costly retakes largely avoided, if the user of photographic solutions will purchase pure chemicals, mix them according to directions, maintain temperatures at 65° to 70°F. (18° to 21°C.), replace used baths before they become overworked, and agitate films, plates, and papers sufficiently when immersing in any solution.

Trays, tanks, film hangers, and all other equipment should be cleaned regularly, and kept in a definite place when not in use. Dry chemicals and stock solutions should be kept covered to prevent access of dust.

PHOTO-ENGRAVING

OSCAR F. KWETT

From the Norothern Engraving and Electrotype Company, Canton, Ohio

[EDITOR'S NOTE: In the December 1932 issue of this JOURNAL there was published the first of a series of articles on processes of reproduction. The first article being "The Full-Tone Collotype Printed Reproduction" by Arthur C. Sias. The following article by Mr. Kwett is a continuation of this series. The object of publishing such articles is to give the biological photographer a working knowledge of the various processes of reproduction, so that he may put this knowledge to good account in choosing or advising the process to be used in the publication of his photographs. The black and white illustrations in this journal were all reproduced by photo-engraving. An article on lithography will be published in a later issue.]

When we speak of engraving, we deal with perhaps the oldest of all crafts. Ever since man has been possessed of intellect, and it is fair to assume that the period extends backwards for thousands of years, a great desire has been to leave his message to posterity. We know that speech has been developed gradually and that our present day verbal language is the result of development extending for thousands of years. While early man found perhaps little difficulty in expressing his thoughts in words, he faced an entirely different situation when he tried to express himself in a graphic manner. Discoveries made recently in the mountains of Spain have brought to light stone tablets bearing inscriptions; in other words, engravings or stone writings that geologists tell us were made fully 50,000 years ago. If that is true, then we may rightfully say

that engraving is the oldest of all art. Engraving and advertising consequently were born at one and the same time.

When the caveman carved his message on stone, he said something about someone or something, himself most likely. These stone writings deal with the writer's prowess in the chase and various other physical accomplishments, and they demonstrate man's constant desire to impart his knowledge to others. Coming down to more recent times, it has been the habit of the printer to claim priority in the Graphic Arts. The Chinese are supposed to have discovered the art of printing several thousand years ago. Although that claim is not well supported, we will qualify the statement and say printing from *movable* types. The discovery of printing as we know it today, is generally credited to John Guttenberg, who, about 400 years ago, astounded the world with his discoveries. But before Guttenberg or anyone else could print, they first of necessity had to have something to print from. In the early days, this was type in every instance, consequently the early printer had to be an engraver perforce, and engrave his own type before he could print from it.

Type is nothing more than a symbol. Our alphabet contains 26 characters, each character symbolizes a certain sound and their combinations make other sounds. In that manner do we create syllables, and with syllables words, and words convey our meaning.

As printing developed, it was found that embellishments of some sort were frequently necessary and always desirable. The engraver of that period (most of them being printers), busied themselves first of all with embellishing the text matter by the use of initial letters and other ornaments of a similar character. This brought still further developments along illustrative lines. Before long, a man with artistic talents would draw a picture upon smooth surface of either wood or metal of some sort, and by removing portions of it, produce in relief, the lines drawn with his pencil or quill. This block when locked up with type could be printed at the same time and with equal facility. From that time, on, the development of illustrations and engravings advanced steadily and today illustrations form a most important part of our present-day literature.

The relation of engraving to printing and advertising is so close that one could not exist without the other. It makes no difference which end of the argument you start with, they are one and inseparable.

Engraving is a basic principle and there are various kinds of engravings. Broadly speaking, they may be divided into two classes, relief plate engraving and intaglio engraving. Relief plate engravings, as the name indicates, means printing plates in which the portions which are to be printed from are left in relief and the other portions removed to a point below the printing surface. This includes wood engravings, wax engravings, and photo-engravings. Intaglio engravings are plates wherein the lines are sunk into the plate and appear below the general surface. Intaglio plates are inked in a manner that forces the ink into the sunken parts, the top surface of the plate is wiped clean and the sheet upon which the printing is to appear is placed in contact with the plate and forced into the sunken portions, sufficiently to extract and hold the ink that has been deposited therein.

HISTORICAL NOTES ON PHOTO-ENGRAVING

The beginning of photo-engraving starts with a line plate made by Joseph N. Niepce, a Frenchman, who made a reproduction of a portrait in 1824; the original plate is still in a museum at Chalons. An impression from the original plate is at the Smithsonian Institute, Washington.

The halftone process may be said to have originated in this country, the first halftone being made by General Frederick W. Von Egloffstein in New York City in 1868. The halftone process received its first real impetus through the discovery of the halftone screen by Mr. Frederick W. Ives, at that time connected with Cornell University, New York.

Mr. Ives discovered an optical substitute for the V-shaped line cut with an engraving tool commonly called a "graver." This optical substitute being the so-called cross line screen or what is commonly known as the halftone screen of today. Mr. Ives announced his discovery in 1876 but apparently did not carry it to perfection because Mr. Max Levy of Philadelphia who was working on the same theory, entirely independent of Mr. Ives, developed and perfected the halftone screen and has been its principal and most successful manufacturer since.

The halftone process was first put to commercial use in 1878. Mr. S. H. Horgan of New York, on March 4th, 1880, produced a halftone engraving, which appeared in the New York Daily Graphic, this being the first halftone to appear in a newspaper, consequently we may say that the halftone process has been in actual use for about forty years.

The three color process is the result of experiments carried on for a

number of years, these experiments assuming definite shape about 1892. In 1893, the first example of three color process work appeared in the public prints and from that time on its development has been both rapid and marvelous.

Mr. W. Kurtz of New York is the one to whom we owe the practical application of the three color theories that had attracted the attention of scientists for years prior to his accomplishments. The first three color plate appeared in the publication entitled, "The Engraver and Printer" of Boston, Mass., March, 1893.

A BRIEF DESCRIPTION OF THE PHOTO-ENGRAVING PROCESS

1. Line engraving

Line engraving or zinc etching, as it is generally termed, represents the first successful efforts of the photo-engraving process. Line engraving is a photo-mechanical process of reproduction from line copy; in other words, from pen and ink drawings or anything corresponding therewith. It is best adapted in the reproduction of wood engravings, steel engravings, lithographs, type, and pen and ink illustrations. The process is as follows:

A copy negative is made from the original. This is brought in contact with a sheet of sensitized zinc resulting in a print on zinc, made upon the same principles as a photographic print on any of the well known photographic papers. In ordinary photography, the negative is placed in contact with a sheet of sensitized paper and the whole exposed to light, the photographic print resulting therefrom. In line engraving it is sensitized zinc, although other metals can be used. Zinc is the most economical, hence the preference. A photographic print on zinc, after being developed is covered with dragons blood, a resinous powder which adheres to the parts that have been exposed to the light and thus forms a protection against the acid with which the plate is etched. It is placed in a large tray, partly filled with a mixture of nitric acid and water, and a rocking motion applied to the tray, allowing the liquid to wash back and forward across the plate, exposing it to the air during the intervals of each rocking motion, which causes rapid oxidization of the metal and aids the speed of the etching. The acid bath, as the liquid is termed, contains in the beginning a small percentage of acid, the etcher adding acid throughout as the work progresses.

Zinc etching is carried on generally in four or more stages each called a

"bite." A new coating of dragons blood is deposited upon the plate after every bite to preserve the illustration proper, to prevent the acid from etching it as well as the waste material. After being etched to sufficient depth, the plate is routed, which means the removal of all waste metal to a point sufficiently deep enough where they will not come in contact with the rollers of the printing press. The routing machine is a drill with a movable head, rotating as high as 15,000 revolutions a minute, thus cutting away whatever surface it is brought in contact with. When routed, the plate is nailed upon a piece of kiln dried cherry lumber, planed down exactly type high, trimmed mechanically to proper size, imperfections are removed by an engraver and the plate is ready for the press.

2. Halftone process

The principal difference between the halftone and line work lies in the fact that the halftone process reproduces continuous tones such as wash drawings, photographs, painting, etc. The word "halftone" is in reality a misnomer, for the halftone process is capable of rendering automatically and photographically, every tone excepting pure white. Pure white can only be rendered by cutting away a portion of the plate and is necessarily hand work. In making a halftone negative, the screen is placed into the camera and immediately in front of the photographic plate. This screen consists of two pieces of glass, each ruled with parallel diagonal lines. The lines are ruled with a diamond tool to a fineness varying from 60 lines to the inch up to about 200 lines to the inch for commercial purposes, although finer rulings are sometimes employed. The ruled sides of the two pieces of glass are placed in contact and in such a manner that the lines cross at right angles. They are then cemented firmly together and form a so-called screen, the light passing from the lens through the screen resulting in a photographic negative or image in which the tone values are rendered by a multitude of small dots. These dots form the etching ground.

Letter press printing can only be accomplished by solid surfaces coming in contact with paper. In other words, if you take up a single type, that type represents a small printing plate, over which the ink rollers pass and which leave an impression upon the paper. These must be of uniform height and while we can render a gray effect through the medium of a halftone, upon microscopical examination, you will find

that each halftone dot is a solid little printing plate and the gray is deepened by placing these little dots in closer proximity to each other. In other words, if you remove all dots from the plate but one and printed that one, you would have a solid black spot on the paper. That explains why the halftone screen is used. Were we to leave the screen out and make a printing plate from a photograph without it, the resultant plate would be what might be termed an impressionistic reproduction of the original because nothing but a black or white would appear. With the screen in use, however, we get the continuous tone, its color being determined by the size and shape of the dots. From this point on, the halftone process resembles that of line work. The halftone negative is placed in contact with the sensitized piece of copper, the latter being the best metal for halftone work. A photographic print is made and the plate is ready for the etcher. In etching halftones, perchloride of iron is used in liquid solution of about 38 degrees strength. The plates are immersed therein and allowed to stand for a sufficient length of time to secure printing depth, this requiring from 15 to 25 minutes. Great claims are made at times for deep halftone etching. As a rule, such claims are merely idle talk, for the depth of a halftone plate is really determined by the negative, for this reason. The halftone dots appear much larger in the negative than they do in the proof taken from the finished plate. This permits of longer etching as the dots gradually became smaller during the etching process. As the plate is etched longer, it becomes deeper. This can only be carried to a certain point, however, for to go beyond means loss of color in the halftone and an over-etched plate, which although it would be deeper than the ordinary, would appear flat and lifeless in the proof. Therefore, if the negative is not made exactly right, a deep plate cannot be secured. The halftone process is purely a mechanical one up to the point of etching. After a plate is etched to where it has sufficient printing depth to permit of both printing and electrotyping, considerable re-etching is necessary. This part of the work calls for skill of the highest character as well as artistic knowledge and feeling, as it determines the reproduction and pictorial qualities of the plate. Judiciously etched, it can at times produce a better production than the original. By that is meant one in which the lights and shades possess more contrast than in the original. In the strict sense of the word, a reproduction can never be better than the original for the original is the standard, the other a replica. After the plate is com-

pletely etched it is turned over to the engravers, who remove imperfections, burnish shadows, tool out highlights, and in other ways increase the contrast of the plate and its printing quality as well. It is then routed and blocked the same as a zinc etching and is ready for the press.

3. Color process work

Color Process work means the reproduction of colored copy by the use of the three primary colors, yellow, red and blue on the theory that all colors can be made from the three primary colors. The colored copy is photographed through ray filters, which exclude all colors excepting the primary one intended for use, viz., in making a negative for the yellow plate, red and blue are excluded and only that portion of the copy in which yellow enters is photographically reproduced in the negative and consequently in the plate. This method is repeated in the red and blue plates excepting that a different filter is used in each instance, since the color separation is different. In all other details, the color process resembles ordinary halftone plate making. For your better understanding, the method of reproducing originals through the medium of color process engraving might be likened to the reproduction of sound as it is done through the medium of phonographs. In reproducing sound, the tonal waves are first recorded on a wax plate or cylinder, hence the name "record." A needle is then applied, which travels over this record and which reproduces the sound. In color process plate making the three primary values are first recorded photographically and then reproduced, and when printed properly, an exact reproduction of the original results.

Four color process plate making is based upon the same theory as three color excepting that a fourth color, black, is added, giving greater density and depth to colors and helping in the reproduction of cold and neutral tones. At the present time, four color process work is the last word in color reproductions. A good many freak plates are made consisting of a combination of line and halftone on one plate. In that case line and halftone negatives are made separately, the films removed from the glass and fitted into one another, combining halftone illustrations, augmented by line borders, inscriptions, etc. Another stunt and one used a good deal by magazine advertisers is what is known as the double printing plate. This work generally consists of an illustration upon which the text matter, titles, etc., appear in type. They may appear in

either black or white. In such cases a halftone negative is made of the illustration, a line negative of the text matter, the negative films are taken from the glass and laid one on top of the other. This results in sharp, clean cut type appearing in the halftone plate, something not easily accomplished if it were turned out by hand, or in the original copy.

PHOTOGRAPHIC TECHNIC, NEW PROCESSES AND EQUIPMENT

F. R. HARDING

From the Children's Hospital, Boston, Massachusetts

LANTERN SLIDES

Lantern slides may be made in three different forms, by contact, reduction, and enlargement. They may be made by contact from any negative which is not larger than the standard area. This greatly limits the negatives that may be employed, unless a print is made, and an enlarged or reduced negative copy is made. Dust is one of the greatest nuisances that occur in making contact slides. It may appear on the negative, or on the glass of the printing frame. Dust causes the appearance of tiny transparent specks on the lantern slide, which are magnified greatly when projected on the screen. There is no satisfactory method of removing these specks by retouching. Lantern slides of line drawings are less apt to present this difficulty.

Lantern slides may be made with a reducing camera more rapidly with greater freedom from dust, less granularity, and better control of shading, than with any other method. Any enlarging camera having sufficient bellows extension may be used as a reducing camera. If the attempt is made, and sufficient reduction cannot be obtained, a lens of shorter focal length should be employed. By using an enlarging camera with a bellows extension of thirteen inches, and a lens with a focal length of four inches, a 5 x 7 negative will reduce to two and five-eighths inches in height. This is ample reduction. If a short focus lens is not available, and the bellows is too short to function properly with the lens at hand, a tube may be fitted to the lens board of the camera, and the lens fastened in the end of the tube. This will, in effect, extend the bellows, and has worked out very well in actual practice. It is not recommended as a permanent feature, unless the extension is rigid, being made of wood or metal, and securely fastened to the lens-board of the camera. A temporary extension may be made from cardboard bound together with lantern slide tape, to prevent leakage of light along the seams. A vertical enlarging camera is operated with more ease than is one which is horizontal. It is easier to place a movable slide block on the bench top, for use with the vertical camera, than to improvise a method of holding a slide block on a vertical easel, such as is necessary with a horizontal camera. Of course, such a camera is operated in red light only. Shading, when

necessary, is accomplished by holding one hand in the path of the projected image between the negative and slide.

The movable block mentioned above should be made of ply-wood to prevent warping, and should be about four by five inches in size. To prepare such a block, a cover glass is placed in the center of the ply-wood block, and a pencil line drawn around the glass. Strips of cardboard about the thickness of a slide are glued on three sides of the pencil markings. A groove is cut in the middle of the pencil line on the fourth side to aid in removing the exposed slide from the board. The cardboard strips forming the guides should be black, so that when the slide block is being moved around to center the image, the boundaries of the slide may be seen. The fourth side may have a black line painted on the wood, equal in width to the card strips. A sheet of coarse sandpaper may be glued on the bottom of the block to prevent it from sliding on the bench top while the unexposed lantern slide plate is being placed in the guides. Focusing may be done on a discarded, undeveloped slide. After the image is focused, the same slide should be turned over so that the glass side is uppermost. The image projected on the glass gives a luminosity to the whole slide, which makes it very easy to see its boundaries, thereby making it less difficult to center the image.

Focusing is accomplished in a different manner when reducing a negative image than when enlarging. To increase the size of the image when making an enlargement, using a vertical camera, the camera is raised as a unit, and the focusing is done by racking the lens away from the easel. When a reduction is being made, the camera is raised, and the lens is racked down. To increase the image size, the camera is lowered. It will be noticed that the camera action in enlarging and reducing are quite different. To make the image smaller when employing a horizontal camera, rack the lens forward and push the easel away from the lens. To enlarge the reduced image, reverse the process.

Slides may be made by enlargement or reduction without an enlarging camera, by employing the regular camera that is used for clinical photography. This may be a "clinical," or a commercial view camera. The negative must be placed on an illuminator of some sort, and carefully masked to prevent any stray light from passing around it. A reducing kit must be placed in the plateholder. Such kits may be purchased from any photographic supply company. The ground glass back of the camera must be accurately marked to correspond to the opening of the kit. The negative image is focused to fill this space properly, and the holder, carrying the slide, is placed in the camera. Some experimenting will be necessary to find the correct exposure. This method works well if the support for both the illuminator and the camera is rigid. If it is not rigid, it will be difficult to get the image in the proper place on the slide, due to movement when the plateholder is inserted in the camera. Such a procedure is very slow, and is not recommended for routine employment, but is satisfactory for occasional use.

The quality of many slides is poor, due to lack of knowledge on the part of the photographer. There is no excuse for the color of the slide being greenish, or brownish black, due to over exposure and under development. The proper tones of a slide should be clear white gradations of gray and black. Another fault is too much contrast. This causes glare and loss of detail when the slide is projected. The

opposite fault is that the slide may be too soft, or lacking in contrast. If any doubt exists as to the quality, match the slide with a good print from the same negative. There should be detail in the highlights as well as in the shadows.

A great many slides are discarded that might be saved by reduction. If a slide is over exposed, develop it the normal time, and fix as usual. Make up a solution of Farmer's Reducer (potassium ferricyanide and hypo), and reduce the slide to its proper density. Local reduction may also be accomplished with this reducer by employing tiny wads of cotton, moistened with the solution. After the reduction, the slide should be placed in the hypo bath for a short time to remove the yellow stain caused by the ferricyanide, and washed as usual. The cost of Farmer's Reducer is far less than the cost of a slide.

When making enlarged or reduced slides, one must always be sure that all sides of the negative are masked to prevent direct light from coming in contact with the slide. Imperfect masking of negatives causes fog around the edges of the slide, and is the actual cause of a great many soft or flat slides. If a slide is much over exposed and is removed from the developer when it is partly developed, it will be extremely flat or lacking in contrast, and the color will be greenish or brownish black. It is difficult to give directions for judging the proper time of development as the emulsions compounded by different manufacturers vary in action. Some slides show the image through on the back very definitely when they are fully developed, while others show no more on the back than a double coated plate developed under the same conditions. The only accurate method of judging lantern slides in development, is by observation of the glass side, as well as by studying it through transmitted red light. If a slide is over exposed and partially developed, it will show proper density when viewed by transmitted light, but will show little or nothing on the glass side. If this slide is rinsed and placed in the hypo and fixed, it will be extremely weak (lacking in density) and flat (lacking in contrast). If this same slide had been developed until the image was well through on the back and then fixed, it would have been too dense (opaque) but could have been reduced and saved.

Slides should always be made so that the base line of the negative is parallel to the edge of the slide, so that the picture will not be diagonal or on a bias, when projected.

Only a part of the total area of a slide is utilized. The standard size of lantern slides in the United States is three and one-quarter by four inches. Many carriers of projection lanterns have an opening three inches square, which is the so-called English opening. However, an additional carrier may be purchased which includes the whole area of the slide. This is called the American opening. Due to the great number of carriers with the English opening, slide images are generally made to conform to this size. There are several methods of masking slides. Ready-cut masks may be purchased. These come in a great variety of shapes and sizes. Uncut masks may also be purchased. These are ruled into tiny squares and may be cut to fit any shape. Still another method is to use lantern slide tape, or passe-partout, for masking purposes. The tape is cut to the length required, and the unwanted portion of the slide masked out. Care must be taken to keep the tape parallel with the edge of the slide. A very convenient way is a combination of two of these methods, that of ready cut mats, and the use of passe-partout. Two sizes, #15 and #18,

of the ready cut mats (Ideal Lantern Slide Mats) are kept at hand. The former is for vertical, and the latter for horizontal slides. All slides are made to fit the longest dimension of the mats. In some cases the other dimension will not fit the mat, and in this event, the surplus space is masked with binding tape or passe-partout. This method has been found to be most rapid, and does not require a large number of assorted sizes of mats.

The binding together of the lantern slide, mat, and cover glass, requires a little experience to get the edges parallel and the corners properly folded, and to have the correct amount of moisture on the binding tape. If the tape is not moistened enough, it will not properly adhere to the glass, or will loosen after exposure to the heat in the projector. If too much moisture is applied, some of the water will be squeezed between the cover glass and the slide. Projection of the slide soon after binding causes moisture to form between the slide and cover glass, which condenses on the emulsion. This moisture, having some of the glue from the tape in it, does not dry as water would do, but leaves tiny translucent spots which clearly show on the screen when the slide is projected. The correct method of binding lantern slides consists of first assembling the slide, mat, and cover glass in a unit. The slide binding, which can be purchased cut to the proper length, is then turned gum side down and passed over a square of damp absorbent cotton. The correct amount of water in the cotton is of great importance, but the amount necessary will have to be learned by experience. Start the binding about an inch from the corner of the slide, on one of the long sides, with the cover glass and slide on edge. Pass the slide end over end down the gummed side of the tape. To make the correct corners, press down the tape on the two long sides first, pressing both front and back sides of the tape at the same time, with the thumb and forefinger. Turn the short side up, and press the tape down in the same manner. Do the same on the remaining side, and the slide is properly bound. If the binding has been done correctly, the tape will be neatly turned under at the corners. The secret of neat corners is always to press down the binding on the long sides first. Place the bound slide on the table, emulsion side uppermost, and with the base line of the slide at the bottom. Place a lantern slide label along the left side, close to the edge, with the dot or "thumb mark" at the bottom, left hand corner. Clean the glass surfaces thoroughly with a soft cloth. Never deliver a slide that is not spotlessly clean. When the unit is being assembled preparatory to binding, make sure that no dust gets in between the glasses. If the slide is bound and dust is discovered, unbind and remove the dust. Never make a slide with the image so small that it does not fill the usable area either vertically or horizontally. Never deliver a slide of any line subject that does not have an absolutely transparent background.

Try to avoid making slides from typewritten material, unless the subject matter consists of very few lines. The type face of a typewriter is very narrow, and is difficult to read on the screen. If typed copy must be used, be sure that it is typed with a good black ribbon, or a fresh carbon copy may serve better for the purpose of copying. The best slides of tables, graphs, or other printed material are made from hand lettered or printed copy. Neat lettering may be done with a mechanical lettering device such as the Wrico Lettering Guides. The letters should be made fairly thick if there is much data to go on one slide. If slides have a great mass

of letters, or figures, to be read by a large audience, the material should be arranged so that two or three slides may be made to contain all the data. In this manner each slide will contain one-third of the material which will be far more easily read than all the same material crowded on one slide. If it is necessary for explanatory purposes, one slide may be made of the entire material, and then additional slides shown of sections of the copy.

Occasionally a request will be made for "feather weight" slides. These slides are two and five-eighths by three and one-quarter inches. This size is carried by many photographic companies. After the slide is made, it is coated with lacquer, and placed in a special metal bound cardboard frame. The lacquer takes the place of a cover glass. Such slides are lighter than the standard size, but, having no cover glass to protect the emulsion, show scratches and finger marks after having been projected two or three times. A number of different methods have been developed which use motion picture film. These films have the same faults as the feather weight slides. Dirt grinds into the emulsion, the film gets scratched, shows finger marks, and has considerable granularity. The author believes the standard glass lantern slide with cover glass, offers the most suitable method of obtaining still pictures for projection.

LETTERING GUIDE AIDS SCIENTISTS IN SECURING PERFECT LETTERING BY HAND

In view of the considerable amount of lettering used by scientists, medical artists and photographers, the WRICO lettering guide illustrated should prove of considerable interest. These guides are available in seven styles and in eighteen sizes ranging in height from 0.090 to 1.0 inch. The flexibility of the equipment is further enhanced by the use of 6 different pens, each making a different width of line.

No previous training or previous lettering experience is necessary to use these guides and consequently the lettering work can be done by an assistant, relieving the principal for more important work. Uniform, perfect, standardized lettering is assured on all work when these guides are used.

The guides may be employed with the WRICO pen (blotting is prevented by a groove in the under side of the guide), pencil, or with the stylus as used for the mimeograph.

These guides are particularly useful for lettering graphs, charts, photographs, negatives, x-ray plates, photo albums or stamp albums and for making titles for film slides in motion picture titles. Every hospital and photographic department should have a set of these guides available.

The guides are distributed by the Warren-Knight Company, Philadelphia, whose advertisement appears in this issue, and from whom descriptive literature may be secured without expense or obligation.

THE AIRBRUSH

The airbrush is invaluable in working up a print for publication. Backgrounds can be subdued, details can be accentuated, and unwanted details can be obliterated. The fine control makes it possible to obtain the softest broad shadows, and the finest of hair lines. Whole drawings can be made solely with the airbrush.

Few photographers realize the value of the airbrush for improving their photographs.

THE CLINICAL PHOTOGRAPHER IN GOVERNMENT SERVICE

It is interesting to note the requirements for the position of clinical photographer with the government under the U. S. Civil Service rules.

At least three years of experience in general photography and one year of experience in photographing normal and pathological organs, living and dead tissues, and in photomicrography is necessary. The salary is attractive.

CLOTH BACKING FOR PHOTOGRAPHIC RECORDS

The problem that for years confronted photographers was to find a satisfactory and rapid method of protecting photographs and keeping them from getting shabby and worn. The old method of cutting muslin to the proper size and applying paste to the back of the print, was a lengthy process and the end result left much to be desired.

A new material was invented and marketed which made cloth backing easy and rapid. This new material is a specially treated cloth that is self adhesive and comes in ready cut standard sheets. It may be obtained from most photographic supply stores.

UNUSUAL DISPLAY OF X-RAY REPRODUCTIONS

Some readers of the JOURNAL may have seen a series of 75 reduced reproductions of lead poisoning cases exhibited at the June meeting of the Pediatrics Section of the American Medical Association by Dr. Edward C. Vogt and Dr. Charles F. McKhann of the Children's Hospital, Boston, Mass. These films were also exhibited at the meeting of the American Radiological Congress in Chicago.

An interesting technique was used in making this series. A 5″ x 7″ reduced positive was made on cut film.[1] From this a negative enlargement was made on 8″ x 10″ X-ray film. The reasons for not making 8″ x 10″ positives, and contact negative films were: it was less expensive to enlarge; enlarging made possible local control during

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[1] Harding, F. R.: Method of Making Negative X-ray Prints for Reproduction. *Jour. Bio. Photo.*, i, no. 3, 156.

the exposure; enlarging eliminated all dust spots. The original X-ray films were of all sizes from 5″ x 7″ to 11″ x 14″. It was necessary to bring the various sizes down to a common size to fit the illuminators in the convention hall. The quality of the reproductions were equal to the original films, and in some films, the quality exceeded that of the originals. The reduced positive films were developed in the regular way, and the enlarged negatives were developed in X-ray developer.

A NEW SEMI-PROFESSIONAL FILMO

A new Filmo Semi-Professional camera has been developed by Bell and Howell. It will appeal particularly to physicians, surgeons, scientists, naturalists, expedition photographers, industrial film producers, and advanced amateurs—in fact, to all of the more serious 16 mm. movie makers who are aiming at professional results.

With its many new features, the Filmo Semi-Professional camera brings a new and broader utility to 16 mm. equipment. Film capacity is increased by the addition of an external 200-foot magazine. This does not interfere with alternate use of the camera by the internal loading of 100-foot spools.

An electric motor, either 12 or 110-volt, provides constantly uniform speed with no periodic pauses for winding. Twelve-volt dry cell batteries are light, compact, and enduring. A synchronous motor can also be fitted for those who have access to recording equipment and wish to experiment in producing talkies.

An 8 to 1 hand crank, usable when the motor is removed, permits continuing a scene after the spring motor has run down. The camera governor controls the speed accurately at any desired point between 8 and 64 frames per second, regardless of whether electric motor, hand crank, or spring motor is used.

For lap dissolves and double exposures, the film may be moved backward with the hand crank. When using the external film magazine, the backward film motion is limited only by the extent to which the spring motor is unwound, the maximum being 24 feet.

A newly designed range finder is built into the camera door. Subject distance is quickly and easily determined. This range finder is accurate to within a quarter inch, for instance, at a distance of three feet.

Seven governor-controlled film speeds—8, 12, 16, 24, 32, 48, and 64 frames per second.

Variable viewfinder, adjustable to match the field areas of six different focal length lenses.

Taking single frame exposures is simplified by provision for locking the starting button gravity catch out of operation.

COMPARISON TABLE OF EMULSION SPEEDS

Burleigh Brooks of 127 W. 42nd Street, New York has prepared a list of the more popular plate and film emulsion speeds. Mr. Brooks will be glad to send this list without charge to anyone interested.

A list of this kind should be of value in determining exposure on a plate or film not habitually used. It takes as a basis, the known speed of the material ordinarily used.

NEW BELL AND HOWELL ACCESSORIES

Bell and Howell Company will install synchronous motors on Filmo 70 type cameras for those who wish to experiment with their own 16-mm. sound recording equipment. If the camera is not already equipped with a hand crank, that must be installed. A flexible cable connecting the motor to the camera to eliminate vibration is also available.

A new Dry Scraper Unit which attaches to any B & H 16-mm. hand splicing outfit in place of the ordinary film scraper guide has been introduced. The blade has 4 cutting edges, and is easily adjusted and locked in place.

Association News

THE 1934 CONVENTION

The Annual Convention of the Biological Photographic Association will be held at the Washington Square College of New York University, New York City, September 13-15, 1934.

Now is the time to gather your data and write an article on some aspect of photography to read at this convention.

Exhibition of prints, apparatus and materials will be placed in the hotel where we will establish headquarters, which will be near Washington Square, one of the most interesting parts of Old New York.

Suggestions for papers on our program and prints for the exhibition are required by your committee in order to make this affair a success. You will be advised from time to time on the progress of our plans. In the meantime, make your prints and hold them in readiness.

Write to Mr. Louis Schmidt, Department of Photography, Rockefeller Institute for Medical Research, New York City, concerning your intention to give a paper or have an exhibit at this convention.

An organization meeting of the Chicago Chapter of the Biological Photographic Association was held at the Chicago Ear, Eye, Nose and Throat Hospital, on February 12. There were thirty men and women present, including Dr. Max Thorek, noted pictorialist and President of the American Photographic Society. Mr. Creer gave a brief talk regarding the history, purpose and activities of the Biological Photographic Association. Mr. William Martenson of the Municipal Tuberculosis Sanitarium, a member of the Association, was appointed temporary chairman for the next meeting of the group. Following the discussions of the activities of the Association, Dr. O. B. Nugent showed motion pictures of a cataract operation and explained the manner in which the picture was made. The Secretary of the Fort Dearborn Camera Club has extended the use of their club rooms as a meeting place whenever desired.

The Third Annual Salon of Photography, under the auspices of the Boston Camera Club, will be held in The Gallery of the Boston Art Club, Dartmouth and Newbury Sts., Boston, Mass., June 21 to July 3, 1934. The last day for receiving prints was May 15, 1934.

Mr. L. Julin and Dr. N. W. Barker have published some experimental work with infra-red medical photography, in the Proceedings of the Staff Meetings of the Mayo Clinic, 9:65–80, Jan. 31, 1934. Mr. Leo Massopust, Director of the Department of Art and Photography at the Marquette University School of Medicine, Milwaukee, Wisconsin, is also doing some fine work in infra-red medical photography.

Mr. William Payne of the New York State Institute for the Study of Malignant Diseases, Buffalo, N. Y., has been preparing some very fine photographic exhibits of malignant disease. The exhibit is in the form of transparencies of the printed case history, the photograph of the lesion and gross specimen, the photomicrograph of the tissue section obtained from a biopsy, or the gross specimen and, the radiograph. Mr. Payne's method is ideal as it perfectly records in a pictorial manner, the essential facts of the case history.

PLEASE RETURN THE CARD!

Your committee, appointed at the convention of the Association, is doing its best to obtain a list of the motion picture films made by the members or used by the members. Postal cards carrying a postage paid return card were sent to 125 members last March. Most of our members have responded but a large number have not yet done so. Please send in your card even though you do not make or use motion pictures so that our records may be complete.

If you did not receive a card and either make or use motion pictures will you please send a card to Dr. Oscar W. Richards, Yale University, New Haven, Conn., advising him of this fact. To all members making or using these films will be sent a record form and the information received will be tabulated and made available to all of the members at the next Convention of the Association. Your committee will make its report as complete and as valuable as the material sent to us makes possible. From the replies received nearly half of the members reporting do make or use motion picture films.

Oscar W. Richards,
B. Earl Clark,
Jean Kieffer,
Committee.

CONSTITUTION AND BY-LAWS OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

ARTICLE I

NAME

The name of this Association shall be Biological Photographic Association.

ARTICLE II

OBJECT

The object of this association shall be to further the study of photography in relation to the biologic sciences, and improve its technic.

ARTICLE III

MEMBERSHIP

Shall be of three classes: namely, Active, Associate and Honorary.

SECTION 1. *Active*—Anyone whose professional duties include photography of biological subjects shall be eligible to active membership and shall be entitled to all privileges of the Association.

SEC. 2. *Associate*—all others who are interested in such photography shall be eligible for Associate membership. They shall have all privileges of the Association except to vote or hold office.

SEC. 3. *Honorary* membership shall consist of persons who are eminent in the collateral sciences and who have made constructive contributions to the art and science of photography. They shall have all privileges of the Association except to vote or hold office.

ARTICLE IV

ELECTION OF MEMBERS

SECTION 1. Application for Active and Associate Membership shall be submitted in writing, either endorsed by two Active Members or accompanied by two letters of recommendation, together with dues for one year ($3.00). Those shall be sent to the Secretary who shall send a receipt to the applicant; record and forward the dues to the Treasurer, and the application and enclosures to the Membership Subcommittee of the Executive Committee for action. This Subcommittee shall promptly notify the President and the Secretary of their decision in favor

of or against the admission of the applicant. The Secretary shall at once notify the applicant of his election or rejection. If not elected, the dues shall be promptly returned to the applicant. A name rejected by the Committee may not be again proposed within a year.

The dues, including subscription to the Journal, shall cover membership to the 1st of July following, and the back numbers of the current volume of the Journal shall be forwarded to the member free of charge.

Article V

OFFICERS

The officers of this Association shall consist of: President, Vice-President, Secretary and Treasurer and eight Directors who, with the above mentioned officers, shall constitute the Executive Committee. The President, Vice-President, Secretary and Treasurer shall be elected annually by the Association; the Directors shall be elected, two to serve for one year, two to serve for two years and two to serve for three years and thereafter two or three Directors shall be elected each year to serve for three years, provided that at no time shall there be more than eight Directors.

Five members shall constitute a quorum.

Article VI

ELECTION OF OFFICERS

A Nominating Committee shall be appointed by the President, at least thirty days before the Annual Meeting, who shall present the names of candidates for the offices of President, Vice-President, Secretary and Treasurer and Directors, at the first business session of the annual meeting. Nominations from the floor shall also be invited. The time of balloting during the meeting shall be decided upon by a majority vote of the members present. Election shall be by ballot.

Article VII

VACANCIES

When vacancies occur through resignation, death or otherwise, it shall be the duty of the remaining officers to fill such vacancies for the unexpired term of office.

ARTICLE VIII

MEETINGS

SECTION 1. The Annual Meeting of the Association shall be held in the Autumn, when the annual program shall be presented, including the regular reports, the election of officers and directors for the ensuing year, and the transaction of any other business.

SEC. 2. Ten active members shall constitute a quorum, until the membership shall have exceeded 100 members, after which ten per cent of the membership shall constitute a quorum.

SEC. 3. Special meetings may be called by the President, or in his absence, by the Vice-President, at the written request of ten per cent of the membership.

ARTICLE IX

AMENDMENTS

This Constitution may be altered or amended by three-fourths vote of the members present at an Annual Meeting, provided notice of such proposed alteration or amendment has been sent to each member and that the proposed alteration or amendment has been before the Society at least one month.

BY-LAWS

ARTICLE I

DUTIES OF THE OFFICERS

SECTION 1. Duties of the President: The President shall preside at all meetings of the Association; shall have the right to vote; approve all bills; sign all documents or papers; appoint all committees not otherwise provided for; be ex-officio member of all committees; shall present an Annual address and perform such other duties as are customary to his office.

SEC. 2. The Vice-President shall preside at all meetings in the absence of the President and assist him in the performance of his duties.

SEC. 3. It shall be the duty of the Secretary to keep a record of all the transactions of the Association, attend to all correspondence, keep a copy of all official letters he shall receive with replies to same, send notice to all members of the time and place of meetings and all nominations, notify officers, applicants for membership, committees and others of their

election or appointment; shall keep a list of all members of the Association together with their addresses.

It shall be the duty of the Treasurer to receive all monies due to the Association, keep an accurate account of same in a book provided for this purpose; shall pay all bills after they have been audited and approved by the President with all receipts, expenditures and vouchers thereof; shall make a full and detailed report of the financial affairs of the Association at the annual meeting or when called for by the President. Notify all members in arrears for dues or assessments and demand payment of the same at least twice while still unpaid during the fiscal year, during which such member becomes in arrears. At the expiration of his term of office he shall turn over to his successor all founds, records, books and property relating to his office and perform all other duties that may be required of him. He shall furnish a bond of one thousand dollars, the premium of which shall be paid by the Association.

Article II

DUTIES OF EXECUTIVE COMMITTEE

Section 1. The Executive Committee shall audit the books and accounts of the Treasurer, recommend such annual assessments as may be necessary to meet the expenses of the Association which shall not exceed the amount of the annual dues.

Sec. 2. It shall be the duties of the Executive Committee to provide a suitable place for meeting, to arrange for papers and other Scientific and professional matters pertaining to the meetings and make a report.

Article III

DUTIES AND PRIVILEGES OF MEMBERS

Section 1. It shall be the duty of each member to support the Officers of the Association for further advancement of Biological Photography.

Sec. 2. The Annual dues of the Association shall be Three Dollars, payable in advance, which includes subscription to the Journal.

Sec. 3. Active members only shall have the right to vote and hold office.

Sec. 4. Honorary members are not subject to fees, dues or assessments.

Sec. 5. Members in arrears shall neither be eligible to hold office

nor entitled to vote at any meeting, nor to the privileges of being notified of meetings. Any member who fails to pay dues for a period of one year, after having received at least two notices, shall have his name stricken from the roll, unless a sufficient reason be given for not forfeiting membership. A suspended membership may be reinstated by a majority vote of the members at any regular meeting upon the payment of all indebtedness.

SEC. 6. The acceptance of membership in the Association implies acceptance of its Constitution and By-laws.

ARTICLE IV

RESIGNATION—EXPULSION

SECTION 1. No resignation shall be considered by the Association until notice to that effect is sent to the Secretary, accompanied by sufficient money to meet all his (or her) indebtedness.

ARTICLE V

PAPERS

All papers read before this Association become its property.

ARTICLE VI

ORDER OF BUSINESS

SECTION 1.

1. Roll Call.
2. Program.
3. Reading of minutes.
4. Report of Officers.
5. Report of Executive Committee.
6. Report of other committees.
7. Unfinished business.
8. Election of Officers (Annual Meeting).
9. New business.
10. Application for Membership.
11. Election of Members.
12. Adjournment.

SEC. 2. The order of business may be suspended by two-thirds vote of all members present.

Article VII

SUSPENSION OF RULES

Rules may be suspended upon the unanimous vote of members present.

Article VIII

AMENDMENT

The By-Laws may be altered or amended by a three-fourths vote of the members present, provided written notice of such proposed alteration or amendment has been sent to each member and the proposed alteration or amendment has been before the Association at least one month.

Article IX

RULES OF ORDER

Robert's Rules of Order shall govern the deliberation of this Association when not otherwise provided for by the Constitution and By-Laws.

NEW YORK CHAPTER OF THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

A meeting of the members of the Biological Photographic Association and their guests was held at The Rockefeller Institute for Medical Research, New York City, on January 30th, 1934, at 8:00 P.M.

A demonstration of gross photography of specimens, low magnifications of cultures and colorless materials was given by the staff of the Illustration Division of The Rockefeller Institute for Medical Research. A resolution was passed that it was desirable to organize a local Chapter of the Biological Photographic Association and a committee was appointed to present a plan at the next meeting which was held on February 27, 1934, at the same time and place. Membership in the Biological Photographic Association is a prerequisite to membership in the proposed local chapter.

It is likely that the Chapter could function with local dues of $1.00 per year and that four meetings would be enough. The local officers would have complete control of policy, programs, and expenditures.

The idea is to bring together workers in Biological Photography and

those interested in it for their mutual benefit and the improvement of their technic. An application blank will be sent to those desiring to become members of the Biological Photographic Association. Persons who are already members of the Association may apply for membership to the New York Chapter by writing to Mr. Louis Schmidt, The Rockefeller Institute for Medical Research, 66th Street and York Avenue, New York City.

Mr. Harold Fowler, of Finlay Color, Inc., explained their method and manipulation, with lantern demonstration; and its application to medical illustration and teaching.

One of our members, Mr. Martin Hagget, told about his work by this process and showed an exhibit of medical subjects. Questions and a discussion was invited.

A constitution and by-laws were adopted and Francis J. Johlfs was elected Chairman, and Harold Altman was elected Secretary and Treasurer. The remaining members of the board were elected at another meeting early in May.

The constitution and by-laws are as follows:

CONSTITUTION

ARTICLE I

NAME AND PURPOSE

The name shall be The New York Chapter of the Biological Photographic Association. Its purpose to promote the interests of the Association and bring the local members together for their entertainment and advancement in craftsmanship.

ARTICLE II

MEMBERSHIP

Any member, in good standing, of the Biological Photographic Association in the Metropolitan area shall be eligible to membership on paying the dues as set forth in the By-Laws.

ARTICLE III

OFFICERS

SECTION 1. The officers of this Chapter shall be Chairman, Vice-Chairman, and a Secretary-Treasurer.

SEC. 2. There shall be an Executive Board consisting of the above named officers together with three directors selected by the chairman.

SEC. 3. The officers shall be elected annually. They shall not serve for more than two consecutive years in the same office.

SEC. 4. The Executive Board shall have power to fill vacancies within its own body.

ARTICLE IV

MEETINGS

SECTION 1. The Annual Meeting shall be held between January 1st. and March 1st. at an hour and place to be designated by the Executive Board.

SEC. 2. Other meetings shall be held at the call of the Executive Board.

SEC. 3. The Executive Board shall hold a regular meeting within two weeks before the Annual Chapter meeting; other meetings at the call of the President.

ARTICLE V

AMENDMENTS

This Constitution may be amended at any regular meeting of the Chapter by a two-thirds vote of members present, notice of proposed amendment having been presented to the Executive Board at its meeting immediately preceding the Chapter meeting and notice having also been appended to the call for the meeting.

BY-LAWS

ARTICLE I

DUTIES OF OFFICERS AND EXECUTIVE BOARD

SECTION 1. The duties of the Chairman, Vice-Chairman shall be those commonly appertaining to such offices.

SEC. 2. The Secretary-Treasurer shall have charge of all correspondence, send out all notices, shall receive all funds and disburse them as directed by the majority of the Executive Board, the individual bills being approved for payment by the Chairman.

ARTICLE II

COMMITTEES

SECTION 1. *Nominating Committee.* There shall be three members; one shall be appointed by the Chairman, one shall be elected by the members of the Chapter, elected at least three months before the Annual Meeting and one shall be from the Nominating Committee of the preceeding year elected by members of that Committee. This member shall act as temporary Chairman and shall call the Committee together for the purpose of selecting a Chairman.

SEC. 2. *Program Committee.* The Chairman shall appoint a Chairman of the Program Committee who, with the Chairman, shall select four members to serve with him. This Committee shall have charge of all programs.

SEC. 3. The Chairman shall appoint an Auditing Committee which shall audit the books of the Treasurer and report at the Annual Meeting.

SEC. 4. Other Committees shall be appointed by the Chairman as occasion demands.

ARTICLE III

ELECTIONS

Officers shall be elected by ballot at the Annual Meeting from Candidates presented by the Nominating Committee or from Candidates nominated from the floor.

ARTICLE IV

DUES

The dues of this Chapter shall be $1.00 payable at the Annual Meeting.

ARTICLE V

AMENDMENTS

These By-Laws may be amended at any regular meeting of the Chapter by a two-thirds vote of members present, notice of proposed amendment having been presented to the Executive Board at its meeting immediately preceding the Chapter meeting and notice having also been appended to the call for the meeting.

ARTICLE VI

SUSPENSION OF RULES

Rules may be suspended upon the unanimous vote of the members present.

ORDER OF BUSINESS

1. Roll Call.
2. Reading of Minutes.
3. Reports of Officers.
4. Reports of Committees.
5. Unfinished Business.
6. Election of Officers (Annual Meeting).
7. New Business.
8. Applications for Membership.
9. Election of Members.
10. For the Good of the Association and Chapter.
11. Adjournment.

Book Reviews and Abstracts

All books or articles to be reviewed must be sent to Mr. C. B. Neblette, care of Eastman Kodak Co., Rochester, N. Y.

The Microscope. SIMON HENRY GAGE. Fifteenth (ultra-violet) edition, 1932. Comstock Publishing Company, Ithaca, New York.

"The Microscope," by Simon Henry Gage, is so well known to all users of the instrument that a review is hardly necessary, except to call attention to the fifteenth (ultra-violet) edition. While this appeared as long ago as 1932, it was felt that the new edition might be unknown to some of the readers of the JOURNAL.

In this new edition, the entire work has been reset, out-of-date illustrations replaced, subject matter revised, and rearranged, and an entirely new chapter on the ultra-violet microscope has been added.

There is a chapter on photographing embryos, or what is frequently termed macro-photography, which within the short space of eight pages, manages to convey a good deal of useful information.

Although this work is concerned essentially with the microscope, more perhaps is called for on the subject of photomicrography than the relatively few pages allotted to this subject. While a whole chapter is devoted to the ultra-violet microscope, photomicrography by ultra-violet light receives somewhat less than a page despite the work of Barnard, Lucas, Köhler and others. Ultra-violet photomicrography admittedly is not at the present time within reach of the average photomicrographer; however, in view of its demonstrated value in technical microscopy, and its inherent possibilities, it would seem to justify more than the passing attention which it has received.

The book, however, as indicated by its title and sub-title, "The Microscope and Microscopical Methods," is concerned primarily with microscopy and within this area is certainly complete and authorative. One can imagine no better work for the user of the microscope, particularly in the biological field.

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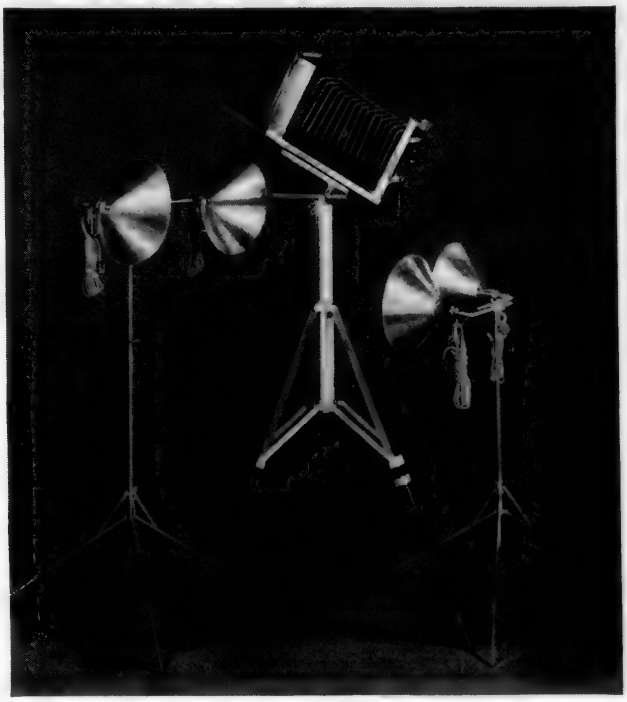

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All matter concerning the Association should be sent to Ralph P. Creer, President, Biological Photographic Association, Department of Photography, Veterans Administration Hosp., Hines, Ill.

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